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Karl Patterson Schmidt
1890–1957

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Karl Patterson Schmidt

1890-1957

KARL PATTERSON SCHMIDT was primarily a herpetologist. He was, in fact, for many years the honored and respected dean of American herpetologists, and during his long career made important contributions to our knowledge of the amphibians and reptiles of the world. Yet to an extraordinary degree he was more than a herpetologist. He liked to refer to himself as a naturalist, which he certainly was, but even this is an inadequate description of the public man and his role in the scientific fraternity. That he was an uncommonly important figure is attested by the honors and responsibilities heaped upon him. In attempting to assess his position we are confronted with a certain difficulty, for we find that he made no important discoveries and expounded no important new theories, that he organized no school of thought and directed no vast enterprises. He himself, with characteristic candor, was the first to recognize this. Whence, then, the stature of the man, the almost universal esteem in which he was held by his fellow biologists? If biography is a vignette of history, perhaps it is our duty to record the facts and leave the interpretation largely to the broader perspective of the historians of the future.

Karl Schmidt was born June 19, 1890, at Lake Forest, Illinois, a suburb of Chicago, where his father was professor of German at Lake Forest College. He died September 26, 1957, following a bite by a boomslang he was trying to identify for a zoo. Karl's ancestory was German on his father's side, Scottish on his mother's. He grew up in the scholarly atmosphere of a college professor's home. Karl was a brilliant student; he graduated from grammar school and from the Lake Forest Academy at the head of his class, and completed his freshman year at Lake Forest College at the head of every class. For family reasons he then dropped out of school, and for the next six years cleared and operated a pioneer farm in Clark County, Wisconsin, acting as head of the family while his father continued teaching in Illinois. Karl himself judged that the most important influences during these early formative years were his mother's active interest in nature, especially botany; three summers spent in camping in the wilds of northern Wisconsin with his father; a year's sojourn in Europe (1895–96), during which he acquired a fluency in German that was a boon throughout his life; and above all the six years spent on the farm. Life on the farm, in the then heavily timbered area of northern Wisconsin, provided abundant opportunities for observation of nature, and it was during this period that he developed the intense interest in nature that characterized the rest of his life.

Already in these early years, and with a minimum of formal training, he displayed a flair for systematic, purposive observation. At fifteen he began records of variation in the genus *Trillium* that continued for six years. At about the same time he was systematically recording weather data on the farm—an interest in meteorology and weather instruments that stayed with him through life. Later this same farm was to be the scene of Karl's greatest personal tragedy, the death of his mother and his younger brother, Frank, in a nocturnal fire that burned the farm house to the ground in 1935. The tragedy might easily have been completely devastating, for his own two sons narrowly escaped death in the blaze. Despite this bitter association, the memory of the early years on the farm was cherished throughout his life, and in his later years he began writing a book—unfortunately never finished—in which the natural history of the farm was recorded. A few years before his death the wooded portion of the farm was deeded to the State of Wisconsin as a conservation area.

Largely at the insistence of Prof. James G. Needham, Karl returned to school in 1913, entering Cornell University as a sophmore at the age of 23. Because of his age and maturity, his life at Cornell was closer to that of a graduate student than to the life of an ordinary undergraduate. He lived with the Needhams, and was quickly drawn into the circle of faculty members and graduate students. His interests centered on invertebrate paleontology, and as he himself said later, his final choice of a career was largely a matter of chance. He made several geological field trips while at Cornell, including an

expedition to Santo Domingo toward the end of his senior year, but his interests embraced all of nature on all of these trips. He intended, at the end of the Santo Domingo trip, to return permanently to the farm, without taking his degree.

Certainly the most decisive event in determining his career was a chance visit to the American Museum in July, 1916, on his way home from the Santo Domingo trip. Here he met Mary C. Dickerson, then in charge of the department of herpetology, and after he had returned to the farm this chance acquaintance led to an offer of a temporary job at the museum, unpacking the huge Herbert Lang collections of amphibians and reptiles from the Congo. Once again we find an outside influence pushing Karl along his curiously reluctant educational way, for Miss Dickerson insisted that he complete the requirements for his B.A. degree from Cornell. Karl remained at the American Museum for six years, first under Miss Dickerson and later under G. K. Noble, and during this period began the studies of amphibians and reptiles that continued throughout his life. Most important were two reports on the Congo reptiles, which established his reputation as a herpetologist and marked the beginning of a life-long interest in animal geography. His interest in animal geography culminated many years later in the book *Ecological Animal Geography* (1937), written in collaboration with W. C. Allee and based on Karl's translation of Hesse's *Tiergeographie auf oekologischer Grundlage*. He worked for many years on a book of his own on animal geography along the classical lines laid down by Wallace, but this project was never completed.

In 1922, Karl took charge of the newly-established Division of Amphibians and Reptiles at the then Field Museum of Natural History (later Chicago Natural History Museum), and over the next twenty years built it into one of the foremost herpetological departments in the world. This was a truly heroic labor, for in those days there were no assistants and no clerical help. He became Chief Curator of Zoology in 1941, and Emeritus Curator of Zoology in 1955. During his long career at the museum he participated in zoological expeditions to various parts of the world: Central America (1923), Brazil, the Argentine, Uruguay, and Chile (1926), Panama, the Galapagos, and the South Pacific Islands (1928–29), Guatemala (1933–34), Peru (1939), New Zealand (1949), and Israel (1953). There were also numerous field trips to various parts of the United States and northern Mexico. It is curious that, except for the brief stay in Israel, he never visited the two continents whose herpetological faunas he studied most extensively: Asia and Africa. In the field his energy, enthusiasm, and range of interest were boundless. Loaded down with gear and equipment, nothing was beneath his attention, and the collections he brought home were likely to include almost anything pertaining to natural history. That he was an inspiring field companion almost goes without saying. Karl's tremendous breadth of interest was reflected in an intense interest in field ecology, so broadly based geographically and so firmly grounded in personal experience that it made him almost unique among modern biologists. In a very real sense he was the old-fashioned naturalist brought down to date. These qualities made him an indispensable member of the team that produced the monumental *Principals of Animal Ecology* (1949). His most ambitious herpetological project was a monograph of the coral snakes. He began this about 1925 and worked at it off and on for the next thirty years. The monograph was never completed, although many shorter preparatory papers on coral snakes were published from time to time. There is a certain symmetry to his herpetological career; at the end he had returned to the beginning and was once again working on a huge herpetological collection from the Belgian Congo.

Among his many responsibilities was an almost continuous succession of editorships, which he enjoyed particularly because of the close contacts with fellow workers that they provided. From 1937 to 1949 he was herpetological editor of *Copeia*. He was a section editor of *Biological Abstracts* from its founding in 1926 until his death. For many years he was an editor of the *American Midland Naturalist*, and from 1941 to 1955 he edited the zoological publications of the Chicago Natural History Museum. He was a department editor of the *Encyclopaedia Britannica* for several years preceding his death. These editorial responsibilities were a minimal burden to him, for in such matters he worked quickly and surely and with a minimum of red tape.

Karl received many honors, particularly in his later years. In 1932 a Guggenheim fellowship enabled him to visit the major European museums for the first time. He

was president of the American Society of Ichthyologists and Herpetologists from 1942 to 1946, and was chosen by the Society to prepare the sixth edition of the *Checklist of North American Amphibians and Reptiles* (1953), the first edition that came out under the auspices of the Society. In 1943 he was appointed Lecturer in Zoology at the University of Chicago. His name was starred in the seventh (1944) edition of *American Men of Science*. He was a member of the Organizing Board of the American Institute of Biological Sciences (1947). He was a delegate to the Sixth Pacific Science Congress in New Zealand in 1949, and a delegate to the Thirteenth International Congress of Zoology at Copenhagen in 1953. In 1950, he was an exchange Professor at the University of Frankfort a/M. In 1952, Earlham College awarded him an honorary D.Sc. In 1954, he was president of the Society for the Study of Evolution. In 1955, a volume of scientific papers by many of his associates was published in honor of his sixty-fifth birthday. In 1956, he was elected to the National Academy of Sciences. The Ecological Society of America cited him as "Eminent Ecologist" in 1957. Karl was often genuinely astonished when one of these honors was bestowed upon him, but they pleased him greatly. Perhaps none gave him more intense pleasure than the honorary doctorate; he had often inveighed against what he regarded as the degeneration of the Ph.D. system and maintained that only the honorary degree now has any meaning. He sadly recognized that the significance of even this has been prostituted by the increasingly common practice of awarding honorary degrees for reasons that have nothing to do with scholarship. The Karl P. Schmidt Fund, to provide grants-in-aid to naturalists, was set up as a permanent memorial to him in 1958.

A notable facet of the Schmidt personality was his intense love of books, a love that had its roots in his childhood environment. The house in Homewood in which Karl lived for the last 35 years of his life literally overflowed with books and magazines, and his quarters at the museum were always crowded with books. I well remember the satisfaction with which he announced, after a bookshelf had been installed in the kitchen, that there was now a bookcase in every room in the house. He accumulated books and papers with the same zeal with which he collected specimens. During his career he built up one of the world's great herpetological libraries, containing more than 15,000 titles, most of which are author's reprints. In turning this library over to the museum he designated it "The F. J. W. Schmidt Memorial Library," in honor of his naturalist brother. Almost as insatiable was his appetite for biographies of naturalists and books of travel by naturalists, and over the years he made a notable collection of these. His contempt for the idea of books as collector's items was profound; to him a book was valuable only to the extent that it was useful. He was likely to explode into profanity at sight of a book with uncut pages.

As a human being Karl Schmidt was almost a paragon of all the virtues. He despised vanity and sham, qualities that tended to be conspicuous in the astonishingly few enemies he made. His love of nature amounted almost to reverence, and led naturally to violent antipathy to those who would deface, waste, or destroy nature for selfish or short-sighted reasons. To him such behavior was quite literally wicked. His sense of compassion was extraordinary, and this was reflected in implacable hatred for anyone, be he corporation executive or merely slick local operator, who sought to enhance his fortune or position by exploiting those less clever—or merely more scrupulous—than himself. This same compassion made him an indifferent judge of men, for his judgment was infallibly biased in favor of the underdog. He loved people, and people in turn loved him. His home life was idyllic, and the Schmidt home on Cedar Road in Homewood was known to a vast circle of friends as a place of charm and simplicity and remarkable warmth. His interest in young people was almost legendary, and a host of those who came under his influence in youth or early adulthood will always revere his name.

Karl was ultra-conservative, and his conservatism expressed itself in many ways—he wore high-topped shoes to the end of his life, he never learned to drive an automobile, he accepted mechanical refrigeration only when it finally became impossible to buy bulk ice, he steadfastly refused to accept television. One of his small conceits was that he had appeared as a performer on more television programs than he had seen. Most of his writing was done with an ordinary steel pen on ruled paper; he never learned to type, and disliked fountain pens. This conservatism stemmed from his own personal

serenity, but it often blinded him to the stern necessity for certain kinds of social change.

Already in his teens Karl rejected the teachings of formal religion, his emancipation coming, he says, "as a kind of conversion." He turned to nature-worship, and throughout his life felt that awe and reverence in the presence of nature was more rational and, to him, vastly more satisfying, than the dogmatic theology of the church. Questions of ultimate causes he regarded as unanswerable, at least in the present state of human knowledge, and therefore—characteristically—ceased to worry about them. This personal philosophy produced a tranquility of spirit, which was nevertheless compatible with insatiable curiosity, that can only be envied by those less successful in coming to terms with life.

There are, of course, many things that Karl Schmidt was not. He had little mechanical skill and little manual dexterity. He had almost no ability in the graphic or musical arts. He had not the slightest interest in sports, either as participant or as spectator. He was an indifferent administrator and executive, partly but not wholly because he was unable to avoid becoming emotionally involved with the problems of his subordinates. From time to time he tried his hand at creative writing, but his style and thinking were unsuited to this and none of the ventures succeeded. He did publish a few short poems, on broad philosophical themes, in the *Scientific Monthly*. Karl was himself vividly aware of these several limitations, and regarded them simply as a part of the framework within which he was required to operate. There was a certain lack of creative imagination, which I believe was one of his weaknesses but at the same time, because it narrowed the channel of his energies, one of his strengths.

The record shows plainly that his peers regarded Karl Schmidt as a biologist of more than ordinary stature. In part this feeling can be attributed to the warmth of his personality, for few could resist his personal charm. But prestige, especially in the sciences, is not based on charm alone, and we must look for something beyond this. I believe his enduring importance will lie in the fact that, in an era of specialism, there is a tendency for the specialist to mistake his tiny isolated fragment of nature for all of nature and to draw stultifying conclusions from far too narrow a base. All too easily such errors can snowball into a body of dogma. If we are ever to understand nature, then the final laboratory where conclusions must be tested, and where stimulating new insights are most likely to emerge, is the vast laboratory of nature itself. Few contemporary men had the breadth and depth of knowledge of nature that Karl Schmidt had, and thus few were so well equipped to counter the myopia of specialism and the absurdities it is likely to breed. This I judge to be the reason for the esteem in which he was held by his fellow biologists.—D. DWIGHT DAVIS, *Chicago Natural History Museum.*

A Bibliography and Index of Karl P. Schmidt's Papers on Coral Snakes

JAMES A. PETERS

KARL P. SCHMIDT'S work on the American species and genera of the family Elapidae extended over 33 years, with his most recent papers appearing posthumously. He authored 17 papers devoted entirely to the coral snakes, and included some data in other papers that were primarily faunal studies or the analysis of a specific collection. In 1932, he held a Guggenheim fellowship which permitted him to examine practically all the types of *Micrurus* species extant in European museums. Shortly thereafter he published preliminary accounts of all the neotropical coral snakes, to be followed by "a more extended publication." This has never been completed, but a considerable series of short papers did follow. The work was laid to one side shortly before the beginning of the World War II, with the statement that it would be wiser to await an opportunity to include the Bassler material in the American Museum of Natural History, which, when studied, would double the number of specimens available.

One is inclined to suspect, however, that the pressure of a multitude of other duties as well as the shortage of specimens from critical areas other than Peru played an equally large part in the discontinuance of the studies. At any rate, both the Bassler collections and research time became available at about the same time; and, in the past five years, he produced a series of papers, each for the most part devoted to the analysis of a single species and its variations.

To any student of the Neotropical herpetofauna, the coral snakes are ineluctable without the benefit of Schmidt's work; even with that work they remain difficult. To facilitate my own work in Ecuador, I have combined all of the papers devoted entirely to the coral snakes in chronological sequence, numbered the pages consecutively, and prepared an index of the scientific names. In this index, subspecies are listed under the species to which they belong, with only a cross reference to that species under the subspecies name, unless it has been used as a binomial. Under each species name are the various generic combinations, also alphabetical; and indented below each genus are the trinomials that have been combined with that genus and species. Here the typical subspecies is listed first, with all others alphabetically after it. I have also included citations to general papers published by Schmidt that included descriptions, definitions, or other remarks on the status of coral snake species under the various species headings, for some of these involve changes in status or clarification of relationships.

The following list of papers includes all those I am aware of that deal directly with the coral snakes. The numbers[1] in the right-hand column refer to the page number that corresponds to the first page of each individual paper in the consecutive sequence of pagination I have utilized. It will be necessary for anyone wishing to use this index to put the papers in the same order as below, and number their pages as cited here. It should be added that this list forms a most satisfactory table of contents for a bound volume on the coral snakes, terminated by the index that follows.

K. P. Schmidt's Papers on Coral Snakes, 1925–1958

[1] Boldface numbers indicate descriptive material. The notation (T.D.) indicates the type description of a taxon named by Schmidt. A number in italics indicates a figure of the taxon.

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Amphibians and Reptiles from Arabia

GEORG HAAS AND J. C. BATTERSBY

MUCH of the recent work on the herpetology of Arabia has been the result of efforts by the late Karl P. Schmidt, and the authors dedicate the present paper to the memory of this friend and colleague.

During the years 1950 to 1953, several collections of amphibians and reptiles were made by Mr. G. Popov, M.B.E., in southwestern and eastern Arabia and presented to the British Museum (Natural History). Among them were two geckoes apparently new to science. These specimens were examined by a number of herpetologists, including Schmidt. In 1957, when Haas visited him in the U.S., they decided to publish a joint description, together with a list of the other specimens in Popov's collections. Dr. Schmidt's death prevented carrying out this project as originally planned.

Popov's collections were made at the following localities (Fig. 1); notes on the localities were made by the collector. Collec-

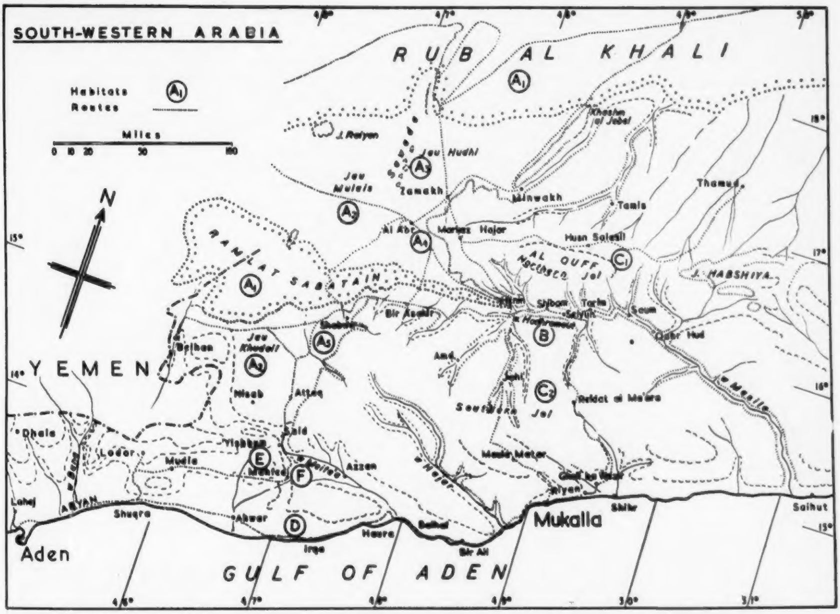

Fig. 1.—Map of Southwestern Arabia, showing localities where collections were made.

tor's field notes on specimens are given in parentheses.

A. Rub al Khali Desert and its fringes.
- A_1. The true sands, dunes up to 300 feet in height.
- A_2. The plain between the sands and the mountains to the south.
- A_3. Sawad hills. An outcrop of metamorphic sandstone.
- A_4. The base of northern Jol. Climate less extreme than in the desert.
- A_5. The base of southern Jol (north side). Similar to base of northern Jol, but altitude lower.

B. Wadi Hadhramaut. Area of Seiyun town.

C. The Jol. A limestone plateau 3,000 to 6,000 feet high, divided into north and south sides by the Wadi Hadhramaut.
- C_1. Wadi Makhiya, northern Jol, 3,500 feet.
- C_2. South Jol, 4,000 feet, east road.
- C_3. South Jol, 5,500 feet, west road.

D. Perennial rock pools and streams in wadis draining south from the mountains.
- D_1. Wadi Yeshbum, 3,500 feet.
- D_2. Wadi Ahwar, 2,500 feet.

E. Dry thorn scrub, 1,000 to 3,000 feet.

F. The south coast.

Ecological Distribution of Species

The species were distributed among the various ecological situations as follows, the letters and numerals corresponding with those in the locality list above.

A. 1. *Phrynocephalus arabicus, Alsophylax blanfordi, Scincus mitranus.*
  2. *Varanus griseus, Pristurus c. tuberculatus, Alsophylax blanfordi.*
  3. *Agama flavimaculatus, Malpolon moilensis.*
  4. *Ceramodactylus major, Acanthodactylus c. arabicus.*
  5. *Malpolon moilensis.*

B. *Pristurus flavipunctatus, Hemidactylus yerburyi, Agama sinaita, Agama flavimaculata, Acanthodactylus b. asper, Tarbophis d. guentheri, Echis coloratus, Bufo dhufarensis.*

C. 1. *Ceramodactylus major, Trachydactylus jolensis, Agama sinaita, Agama jayakari, Uromastix microlepis, Chamaeleo calcarifer, Psammophis schokari.*
  2. *Pristurus flavipunctatus, Agama adramitana.*
  3. *Pristurus c. collaris.*

D. 1. *Rana cyanophlyctis ehrenbergii.*
  2. *Bufo orientalis.*

E. *Ptyodactylus h. hasselquistii, Agama flavimaculata.*

F. *Ceramodactylus major, C. doriae, Pristurus c. collaris, Hemidactylus shugraensis.*

List of Species

Amphibians

Rana cyanophlyctis ehrenbergii Peters.—Two adults, one larva, and one young from Wadi, near Yeshbum (very common). Four adults, Hofuf, E. Arabia.

Bufo dhufarensis Parker.—Two females Wadi Hadramaut (appears to be mainly nocturnal).

Bufo orientalis Werner.—Nine specimens Wadi Ahwar (abundant in grass bordering the streams).

We are indebted to Miss A. G. C. Grandison for identifying the amphibians.

Reptiles

Alsophylax (Bunopus) blanfordi Strauch.—One male, Zamakh, E. Aden Province; 1 male, 50 miles N. of Zamakh; 1 male, Savead, E. Aden Province; 1 female, Lat. 18° 30′, Long. 48° 50′, S. Arabia. (Found deep in the sands of the Rub-al-Khali, hiding under bark of bushes during the day and running about at night).

Ceramodactylus doriae Blanford.—Three males, 90 miles E. of Aden.

Ceramodactylus major Parker.—Four specimens, Wadi Hajar (fairly common), 2 males, Wadi Saleim, near Zamakh; 2 specimens, Jol, N. of Zamakh; 3 males, Beihan, W. Aden Province; 1 male, Jav-wadi, Hadramaut; 2 males, and young, W. Rama.

Hemidactylus shugraensis, *sp. nov.*

Fig. 2

Type.—British Museum (Natural History) 1953.1.6.97, adult male, from Shugra, West Aden Protectorate. Collected by G. Popov.

Paratype.—British Museum (Natural History) 1953.1.6.98, adult male, same locality and collector.

Diagnosis and description.—A form of *Hemidactylus* related to *turcicus,* but distinguished by the following characters: Rather small trihedral tubercles on back, gradually diminishing in size on the flanks. Mental rounded posteriorly, the rounded end not enclosed by chin shields but in touch with the granular gular tubercles. A single pair of chin shields, widely separated from each other but in contact with both mental and first infralabial, and in one specimen with second labial. The most anterolateral gular granules slightly enlarged but not enough to be considered chin shields. Ventral scales much smaller than in *H. turcicus* of equal size from Hadramaut; counted lengthwise, one half centimeter contains 14 ventral scales in *shugraensis* as against 9.5 in *turcicus.* First supralabial excluded from naris by an anterolateral prolongation of the third nasal; first nasals the largest, and extensively in contact behind the half-cleft rostral. Five preanal pores, arranged in a reversed V-like pattern. No enlarged scales on undersurface of tail, all ventral scales being of equal size like their more lateral neighbors. The large conical scales on the tail much less prominent than in *H. turcicus* from Hadramaut; even the smaller ventral scales are much smaller than in the specimen compared.

(Collected at light on acacia trees and bare ground. Appears to be common, at least locally).

Hemidactylus turcicus turcicus Linnaeus.—Three specimens, Hofuf, E. Arabia.

Hemidactylus yerburyi Anderson.—Two males, Wadi Hadhramaut, Seiyun. The rows of tubercles in these specimens number less than in typical *yerburyi,* 12 as against 16, as do the number of femoral pores, 4 as against 12–15. The chin shields are more like those in *yerburyi* than in *turcicus.* (Very common in many villages).

Pristurus carteri collaris Steindachner.—Four females, near Shugra, Y. Aden; 1, Haura, S. coast; 2 females, and young, Wadi Hajar; 1 young, Jol, near Mowla Matar, Hadramaut (nocturnal); 1 young, Shugra, E. of Aden. The rostral and mental are both very pointed in these specimens.

Pristurus carteri tuberculatus Parker.—One young male, Zamakh, E. Aden Province; 6 adults, and young, N. Jol.

Pristurus ?flavipunctatus Rueppel.—One young, S. Jol, north of Muka, Hadramaut; 1 young, Seiyun, Wadi Hadramaut. Both these specimens are young and are identified as *flavipunctatus* with some reserve. The tail is not denticulate, but the legs are short as in *flavipunctatus.* The coloration does not quite agree with the other British Museum specimens under this name. (One of the commonest lizards in the area. Only gecko found during the day).

Ptyodactylus hasselquistii hasselquistii Donndorff.—Two females, Mahfid, W. Aden Province. (Found on a large *Sterculia* tree).

Fig. 2.—Type specimen of *Hemidactylus shugraensis*, dorsal and ventral views.

The single specimen discussed in the following description proved most perplexing to the many workers who have examined it. It shows a strange mixture of characters found in several geckonid genera, namely *Stenodactylus*, *Ceramodactylus*, and *Gymnodactylus*. It will be introduced here as

Trachydactylus, *gen. nov.*

Habitus rather like *Ceramodactylus* or *Stenodactylus*, but tail with whorl-like arrangement of scales. Digits slender, with pectinate lateral fringes; ventrally one series of transversely elongated palmar plates, covering the whole ventral surface of fingers and toes. Each plate exhibits, close to its distal border, three knoblike elevations; smaller knobs, likewise transversely arranged, near proximal border, but their number is variable. On the sole of hand and foot a group of enlarged polygonal scales, each one with a central knob and a peripheral ring of smaller ones. Scales bordering ventral plates of digits ending in two cusps each. Subdigitals with

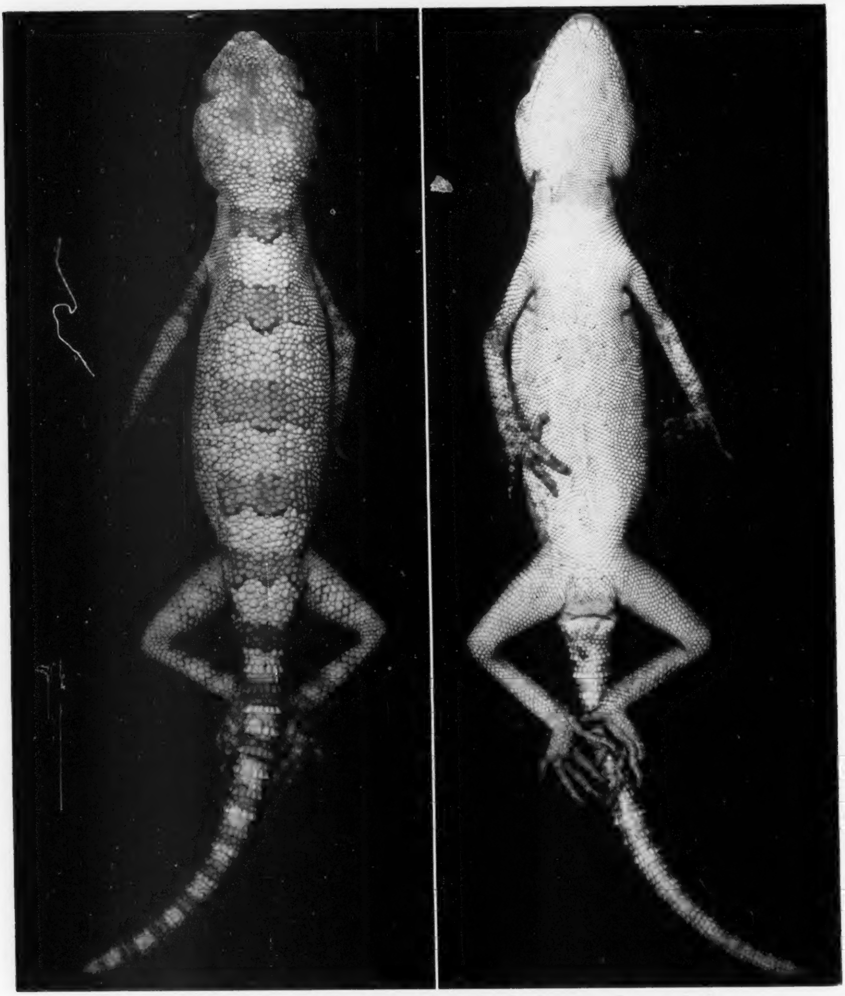

Fig. 3.—Type specimen of *Trachydactylus jolensis*, dorsal and ventral views.

transverse, straight or slightly concave borders distally. All scales of ventral side of body, femora, and neck with a subterminal pore, 2–3 pores at anterior border of femur in each scale. A dorsal area covered with very large scales. No chin shields. Tail surrounded by whorls of scales, each one composed of 3 rings of scales, 2 proximal rings of equal size followed by 1 enlarged ring of scales forming distally bulging, sharp keels that do not go beyond the slightly rounded posterior border, whorls becoming more distinct distally. Type species *Trachydactylus jolensis.*

Trachydactylus jolensis, *sp. nov.*
Fig. 3

Type.—British Museum (Natural History) 1953.1.6.96, adult female, from Jol, north of Zamakh, Hadramaut, S.W. Arabia. Collected by G. Popov. Total length 100.5 mm., head and body 57, head 16.5. Width of head 12.5. Forelimb 25, hind limb 33.

Description.—General habitus of a *Stenodactylus* or *Ceramodactylus*, but differing in its very coarse dorsal scalation and entirely different scalation on the plantar surfaces of the fingers and toes, somewhat resembling

Gymnodactylus. Head cordiform, rather large, with distinct neck constriction; snout bluntly pointed, longer than horizontal diameter of orbit, approximately as long as distance between eye and ear opening. Eye with a dark colored ring around the outer circle of the brill; a dark >-shaped mark posteriorly to the narrow vertical opening of the pupil. Ear an oblique, narrow slit, the anterior and ventral at angle of 60°. Body rather short and stout, not depressed. Limbs slender and elongate, digits moderately slender, flattened ventrally, equally rounded dorsally and on both sides (in transverse section). Outstretched forelimb reaches beyond snout, fails to reach the groin. Outstretched hind limb just reaches beyond the shoulder. Digits slender, slightly angulate. Claws of moderate size.

Number of Subdigital Plates

Digit Number	Fingers	Toes
1	13	12
2	13	14
3	15	16
4	15	17
5	12	16

The subdigital lamellae cover the whole plantar surface of fingers and toes; each plate shows 3 equidistant knoblike elevations near the distal margin; proximally a more or less transverse series of much smaller knoblike elevations. Plantar surface of both limbs covered by a mosaic of polygonal scales, each exhibiting a central knob and a peripheral row of smaller knoblike elevations. Proximally these juxtaposed scales gradually transform into imbricating, longitudinally keeled elements on lower leg, more rounded elements on forearm, with a blunt keel produced to the center of the scale (distal half smooth). Six scales around fingers and toes, all carinated, except the subdigital lamellae described above. The scales in contact with the subdigital lamellae split distally into 2 cusps, which do not protrude as a pectinate fringe.

Head covered with rather large, irregularly polygonal, juxtaposed shields, partly smooth, partly slightly rugose. The latter form an interocular, narrow dorsal stripe, broadening in the parietal area. Supraocular shields largest, but smooth. Scales on top of snout slightly elongate, somewhat bulging. A group of very small elements in front of eyes. Temporal elements of irregular size, rounded, with small rounded tubercles in the interstices between the larger elements.

A single, circular eyelid; some bulging trigonal, pointed scales at posterior dorsal corner of orbit. The largest scales at the anterior end of upper rim of the eyelid, forming 3 longitudinal series. Rostral completely cleft. Naris between rostral, first labial, and 3 nasals, the share of the posterior largest.

Supralabials 13–13; infralabials 11 + 1?–12. A bluntly triangular symphyseal (mental) protruding between pair of first infralabials; no clearly differentiated chin shields, but one pair of gular granules in corners between symphyseal and first infralabials largest, the following gular granules gradually reducing in size. Lower temporal scales (between eyes and tympanic opening) much smaller than dorsal ones, horizontally elongated, with exception of a few posterior, much larger, rounded tubercular elements in front of ear opening. Gular and submandibular very small, juxtaposed, pointed tubercles. Dorsal scales on body largest, even the smallest among them (laterally) larger than the ventral scales. A straight line of scales from axilla to groin clearly separates a dorsal area from the ventral field. The largest dorsomedian scales are irregularly arranged but a more or less transverse arrangement is observable more laterally; the large scales extend caudally to the base of the tail. Almost all dorsal scales with straight or angulated, rarely rounded, posterior border; many are slightly keeled at the anterior part of scale. The keel never reaches the posterior margin. Between these juxtaposed scales remain irregular scaly interstices, forming a pattern resembling the wrinkles on the upper side of the human hand. There is not the slightest imbrication. Interstitial scales, more obvious in the dorsal area, occur as well on the dorsal surface of head and in the temporal region.

Under the horizontal series, forming the border between dorsals and ventrals (no skin fold underlies this structure) start abruptly the much smaller ventrals, arranged in transverse tiers laterally, which protrude in an arrowlike fashion medioventrally. In the mid-ventral pectoral area (coracoid area), a more or less rhombic area of slightly enlarged, more granular scales, arranged abruptly in strictly transverse series. The cranially directed ventro-median angular series not quite regular; many transverse lateral series of scales are interrupted, a part only forming the ventro-median angulations. Ventral scales elongated and keeled, a pit at the

posterior end of each; similar pits up to cloaca, underside of femur, on gular granules; 2–3 pits at distal end of anterior ventral femoral scales. Scales in pectoral field bluntly keeled. On upper side of limbs imbricating, keeled scales in regular serial arrangement. Five slightly enlarged smooth scales forming a transverse series between bases of hind limbs. At either side of the base of the tail 2 enlarged, bluntly conical tubercles, the second deeper than the first.

Tail not whiplike; posterior to the base, which is fairly thick and not tapering, there is a sudden constriction at the level of the enlarged lateral tubercles, followed by a very gradual tapering; even the tip is rather blunt. Scalation composed of whorls, each consisting of 3 circles of scales, those of the first two of equal size, those of the third enlarged (in antero-posterior direction), composed of narrower keeled elements. The keel gradually sharper caudally, but not going beyond the rounded posterior margin of the scale. Whorls beginning at the constricted part of the tail (the root), and becoming more elaborate distally.

Color in alcohol.—Head and neck dull brown, body of a more grayish hue; several darker gray transverse bands, the first rather brownish, in front of shoulder on neck, the 3 following crossing the body, the fifth across the pelvic region; each band clearly marked posteriorly by a darker brown line except the pelvic band, which instead has 3 darker posterior dots in symmetric arrangement. Tail with brown, evenly-spaced crossbands, without any correspondence with the whorls of scalation. Upper surface of limbs with brown markings on gray basic color. Ventrally white. The brown field of the upper side of the head covers the temporal area, and upper lid. Two pairs of mandibular blotches, one beneath the ear opening and one beyond the caudal infralabials.

(Uncommon; no more specimens could be found although looked for).

Agama adramitana Anderson.—One male, hill 50 miles north of Mukalla, Hadramaut. (Fairly common, living on rocks).

Agama flavimaculata Rueppel.—One female Samad, E. Aden Province; 1 male, Said, W. Aden Province; 1 male, Seiyun. (Common, usually on bare soil). 1 half-grown female, Hofuf, E. Arabia; 1 female, Jabrin, E. Arabia.

Agama jayakari Anderson.—One young, N. Jol, Hadramaut.

Agama sinaita Heyden.—Two males, 1 half-grown female, near Zamakh, 4,000 feet; 1 male, 2 young, Seiyun; 1 male, N. Jol, Hadramaut. (Common; frequently seen on bushes).

Phrynocephalus arabicus Anderson.—Four females, half grown, Zamekh; 1 male, 17° 12′ N, 45° 50′ E.; 1 male, 18° 20′ N, 49° 50′ E. (One of the commonest diurnal lizards).

Phrynocephalus maculatus Anderson.—One female, Shabwa, S. Arabia.

Uromastix microlepis Blanford.—Two young and skin, N. Jol, Hadramaut.

Uromastix philbyi Parker.—One young (no locality label).

Varanus (*Psammosaurus*) *griseus* Daudin.—One young, Zamakh. (Encountered occasionally).

Acanthodactylus boskianus asper Audouin.—Two males, Seiyun.

Acanthodactylus cantoris arabicus Boulenger.—One male, Zamekh; 1 male Hasa, E. Arabia. (*Acanthodactylus* is the commonest lizard in the area, including the desert).

Chalcides ocellatus ocellatus Forsk.—One young, Shugra, Aden coast. 60 miles E. of Aden.

Scincus (*Arenatius*) *mitranus* Anderson.—Seven adults, half-grown, and young, Zamakh; 1 half-grown, Shugra, Aden coast, 60 miles E. of Aden; 1 adult, Hofuf, E. Arabia; 1 adult, Jubril, E. Arabia. These specimens show considerable variation in the dark horizontal banding.

Chamaeleo calcarifer Peters.—One adult, Jol.

Malpolon moilensis Reuss.—One half-grown male, Bir Asakir. Dorsal scale rows 17, ventrals 163 + 2, caudals 63; 1 (minus head), Jol; 2 specimens, Jabrin, E. Arabia. Dorsal scale rows 17, 17; ventrals 168 + 2, 171 + 2; caudals 60 +, 52.

Psammophis schokari Forsk.—One female, Jol, 4,000 feet. Dorsal scale rows 17, ventrals 179 + 2, caudals 117.

Tarbophis dhara guentheri Anderson.—One male, Seiyun. Dorsal scale rows 21, ventrals 242 + 1, caudals 66. (Complete undigested sparrow extracted from gut).

Aspis cerastes Linnaeus.—One female [skin], Jabrin, E. Arabia. Dorsal scale rows 26, ventrals 160 + ?, caudals 33.

Echis coloratus Guenther.—One young, N. area of Hadramaut. Dorsal scale rows 33, ventrals 177 + 1, caudals 54.

THE HEBREW UNIVERSITY, ISRAEL, AND BRITISH MUSEUM (NATURAL HISTORY), LONDON, ENGLAND.

New Plethodontid Salamanders of the Genus *Thorius* from Puebla, Mexico

FREDERICK R. GEHLBACH

HIGH mountains on the southern edge of the Mesa Centrál in Puebla, Oaxaca, and western Veracruz have isolated mesically adapted species in many groups of the Mexican herpetofauna. This is especially true in the Amphibia where such diverse genera as *Pseudoeurycea, Microbatrachylus,* and *Hyla* have one or several "insular" species in the region. Thoriine salamanders are no exception for ten forms occur in humid habitats between the Mesa Centrál and Isthmus of Tehuantepec. At three Oaxacan localities, near Acultzingo in Veracruz and Pájaro Verde, Puebla, two or more species of *Thorius* may be taken together, but for the most part, the various forms are widely separated. The occurrence of two undescribed species near Zoquitlán, Puebla, is a sixth record of sympatry in *Thorius.*

In recognition of his outstanding contributions to North American herpetology, including early work on the genus *Oedipus* of which *Thorius* has been part, the first species is named for the late Karl P. Schmidt.

Thorius schmidti, *sp. nov.*
Fig. 1, A–B

Holotype.—United States National Museum No. 140295, an adult male collected at *ca.* 8,400 feet, four miles west of Zoquitlán, Puebla, Mexico, on August 14, 1954, by Fred C. Sibley. Original field number 124.

Paratypes.—Nine specimens, USNM 140296-300, same data as type; E. H. Taylor Nos. 36523-5, taken August 12, 1954, and Cornell University No. 6299, taken August 13, 1954, at the type locality.

Diagnosis.—Related to *Thorius pulmonaris* and *T. macdougalli* in having an elongate oval nostril but differs in the following characters: larger size, largest snout-vent length 30.5 mm.; longer tail, greatest length 40.5 mm.; presence of a large number of maxillary teeth (6–12); snout bluntly truncate, not pointed or rounded as in *pulmonaris*; digit tips more nearly rounded than in *pulmonaris*; canthus not produced as in *macdougalli.*

Description of type.—The snout is broadly and bluntly truncate, protruding so that the ovate lower jaw is somewhat inset; nostril large and elongate, oval in shape, diagonally placed with respect to eye; canthus moderately sharp but anteriorly obscured by dorsal rim of nasal opening; shallow nasolabial groove on a slight subnarial swelling; eye quite large, about 1.25 times snout length; a deep orbitolabial groove joining angle of jaw at a point even with posterior edge of eye; from that point another groove runs caudally for 0.7 mm.; minute groove at posterior corner of eye is V-shaped; the prominent gular fold joins lateral nuchal folds which meet at the middorsal depression; a small prenuchal fold does not cross the throat but runs up the sides of the head to about eye level; dorsally behind orbits a shallow V-shaped depression extends caudally for 1.8 mm.; maxillary teeth 10 on each side; premaxillary teeth 8, somewhat larger than maxillary teeth; mandibular teeth 46; vomerine teeth 5 to a side and separated from two elongate, slightly separated, club-shaped paravomerine tooth patches each of which has about 50 teeth; sublingual fold present; tongue boletoid; choanae narrow with narrower lateral grooves extending caudally.

The body is elongate and rounded, greatest trunk diameter 3.7 mm.; 13 costal grooves; tail round at base, not constricted but tapering and becoming oval in shape; 37 caudal grooves; longest digits rounded, outside toes truncate and rather spatulate at tips, only the tips and distal phalanx of longest toe free from webbing; the toes, which do not taper appreciably are in the following order of increasing size: 1, 5, 2, 4, 3, and the fingers: 1, 4, 2, 3; limbs small, the hind limbs only slightly stouter than fore limbs, when adpressed, digit tips separated by 6 costal folds; skin evenly pitted with minute circular glands; color (in alcohol) reddish brown with a light brown dorsal band 2.5 mm. wide at midbody and darker dorsolateral band 1.0 mm. wide at same point, these bands beginning behind eye and becoming diffuse on base of tail; venter lighter with numerous scattered whitish flecks which are concentrated at bases of the limbs.

Measurements (in mm.): snout-vent, 28.8; tail, 37.9; axilla-groin, 16.7; snout-arm, 7.8; snout-gular fold, 4.7; head width, 3.6; eye

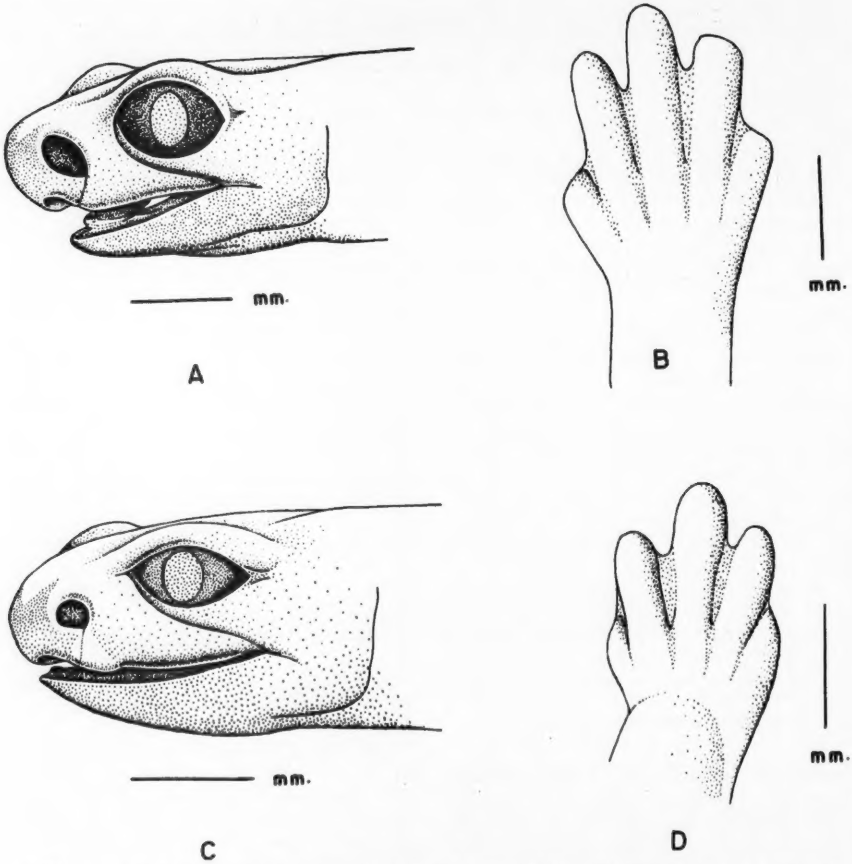

Fig. 1.—A–B *Thorius schmidti*, type; C–D *Thorius maxillabrochus*, type. A and C show the left side of the head from snout to prenuchal fold; B and D are the right hind foot.

length, 1.1; greatest nostril diameter, 0.6; arm and hand, 4.7; leg and foot, 5.2.

Variation in paratypes.—All nine specimens collected with the type are also males so that sexual dimorphism if any is not known. They are similar in coloration except for degree of ventral spotting. The number of maxillary teeth ranges from 6 to 12, premaxillary teeth 5 to 8. Several specimens are poorly preserved. These are either soft or excessively hardened and discolored; some measurements and color description may therefore be inaccurate. Mensural characters of the eight adults (mean and range) are summarized below. Four specimens have complete tails. Measurements of the single juvenile follow those of the adults. Snout-vent (27.1) 23.2–30.5, 18.3; tail (37.0) 27.5–45.3, 19.1; axilla-groin (15.2) 13.6–18.0, 9.7; snout-arm (7.3) 5.8–8.3, 5.3; snout-gular fold (4.8) 4.5–5.2, 3.6; head width (3.4) 3.0–3.7, 3.6; eye length (1.2) 0.9–1.3, 0.8; greatest nostril diameter (0.69) 0.60–0.75, 0.45; arm and hand (5.0) 4.3–5.8, 3.3; leg and foot (5.7) 5.0–6.1, 4.0.

Distribution.—Known from the type locality only.

The second species, represented by two specimens, is strikingly different from *T. schmidti* in size and in toe and nostril configuration. Unlike other members of the genus (except *schmidti*) it has prominent maxillary teeth and may therefore be known as

Thorius maxillabrochus, *sp. nov.*
Fig. 1. C–D

Holotype.—USNM 140293, an adult male collected at *ca.* 8,400 feet, four miles west of Zoquitlán, Puebla, Mexico, on August 12, 1954, by Ralph H. Long, Jr. Original field number 67.

Paratype.—USNM 140294, same data as type.

Diagnosis.—A member of the *narisovalis* group having an oval nostril, but differing in the large number of premaxillary (4) and maxillary (9–12) teeth present. Furthermore, it may be distinguished from *dubitus* by the more rounded tail and pitted head, from *narisovalis* by the reduced outer toe and smaller nostril and body size, from *minutissimus* by the separated, rounded toes and larger size; and from *troglodytes* by the reduced outer toe and darker coloration.

Description of type.—The snout is roundly truncate; the lower jaw ovate but slightly pointed at tip and countersunk; nostril small, oval; a shallow nasolabial groove on a moderately large subnarial swelling; eye about equal to snout length; deep orbitolabial groove joins angle of jaw at a point slightly caudad of posterior edge of eye, from that point a minute groove extends caudoventrally; slight V-shaped groove behind eye; canthus somewhat obscured by dorsal rim of nasal opening; a slight prenuchal fold does not cross the throat but extends dorsally to the eye level; prominent gular and lateral nuchal folds continuous, these meeting dorsally at the deep middorsal groove; dorsally behind the orbits a small raised V-shaped area extends caudally for 1.5 mm.; maxillary teeth, 10–12; premaxillary teeth not visible; mandibular teeth, 39; 5 vomerine teeth separated from two elongate, club-shaped paravomerine tooth patches each of which has about 40 teeth, these patches only slightly separated posteriorly; sublingual fold present; tongue boletoid; choanae narrow with narrower lateral grooves extending caudally.

The body is moderately elongate and rounded, greatest trunk diameter 3.4 mm.; 13 costal grooves; tail squarish at base, not constricted, tapering and becoming rounded; 27 caudal grooves; all digits rounded and webbed except for extreme tips, outer toes much reduced; the digits have a slight taper and the toes increase in size in the following order: 5, 1, 2, 4, 3, the fingers: 1, 4, 2, 3; limbs small, the hind limbs slightly stouter than fore limbs, when adpressed the digit tips separated by 7.5 costal folds; skin evenly pitted with minute circular glands; color (in alcohol) reddish brown with a lighter dorsal band 2.2 mm. wide at midbody and darker dorsolateral band 0.5 mm. wide at same point extending onto base of tail from side of head behind eye; venter somewhat lighter than dorsal band; a postiliac light spot present.

Measurements (in mm.): snout-vent, 24.3; tail, 23.5; axilla-groin, 13.7; snout-arm, 6.3; snout-gular fold, 4.1; head width, 3.2; eye length, 0.8; greatest nostril diameter, 0.45; arm and hand, 3.4; leg and foot, 3.9.

Variation in paratype.—This specimen, a male, is patterned like the type except that some ventral whitish flecking is apparent. As in the type series of *T. schmidti*, this specimen and the type of *maxillabrochus* are slightly discolored and may have been lighter in life. Counts and measurements (in mm.) are snout-vent, 24.5; tail, 28.2; axilla-groin, 14.3; snout-arm, 6.6; snout-gular fold, 4.4; head width, 3.1; eye length, 0.8; greatest nostril diameter, 0.40; arm and hand, 4.0; leg and foot, 4.4; maxillary teeth, 9–10; premaxillary teeth, 4; vomerine teeth, 6; mandibular teeth, 46; costal grooves, 13; caudal grooves, 32.

Distribution.—Known only from the type locality.

Remarks.—All specimens of *schmidti* and *maxillabrochus* were taken under wet, rotten pine logs on a steep slope with western exposure as described by Gehlbach and Collette (1957). It is noteworthy that a large and small-nostril species are associated as in some other areas of sympatry. In both species peritoneal mesenteries and testes are darkly pigmented. The curious absence of females may indicate that they congregate other places more suitable for egg-laying. This probably occurs in all *Thorius* from April through the summer period of heaviest rainfall. Enlarged eggs have been found in *macdougalli* collected April 2–3 and July 23–27, 12 miles north of Ixtlán de Juarez, Oaxaca, 9,200 feet; and in *pulmonaris* and *narisovalis* taken July 5, 3.5 miles south of Rancho El Punto, Oaxaca, 8,400 feet. Male *macdougalli* were generally smaller than the females and possessed larger subnarial swellings and a distinct mental gland.

Concerning relationships there appear to be three, variously well-defined groups within the genus *Thorius*. The species *narisovalis, dubitus, troglodytes, minutissimus,* and *maxillabrochus* all have rounded toes, large oval nostrils and slight subnarial

swellings. *T. pulmonaris, macdougalli,* and *schmidti* are alike in having well-developed, more or less rounded toes, and the characteristic oval, greatly elongated nostrils. The third group containing *pennatulus* and its subspecies *narismagnus* has pointed toes, prominent subnarial swellings and circular nostrils. Whether these are natural assemblages is not clear at present, for there is striking convergence of taxonomic characters in all species. Indeed, the apparently unique presence of maxillary teeth in *schmidti,* and *maxillabrochus* may be modified by age and sex. It is emphasized that nine forms of *Thorius* (excluding *T. pennatulus narismagnus*) are clearly separable when one has sufficient comparative material at hand. However, character geography based on known populations suggests that certain of the species, especially those in the *narisovalis* group, might be relegated to subspecific status when more material becomes available.

Five new forms of *Thorius* have been described since the last publication of a key (Smith and Taylor, 1948: 16). The following revised key is therefore presented.

Key to Adult Salamanders of the Genus Thorius

1. Nostril very large, oval, elongated, may be nearly twice as long as wide 2
   Nostril large, round or oval, never greatly elongated 4
2. Size small, maximum snout-vent length 25 mm.; not more than 30 caudal grooves; canthus sharply produced or not; digit tips rounded .... *macdougalli*
   Size large, maximum snout-vent length 32 mm.; more than 30 caudal grooves; canthus not produced; digits rounded or pointed 3
3. Snout bluntly truncate; maxillary teeth present; digit tips rounded; nostril never twice as long as wide .... *schmidti*
   Snout pointed or rounded; no maxillary teeth; digits somewhat pointed; nostril may be twice as long as wide .. *pulmonaris*
4. Nostril oval; digit tips rounded; subnarial swelling not or only slightly pendant ... 5
   Nostril circular; digits pointed; subnarial swelling prominently pendant 9
5. Size large, maximum snout-vent length 32 mm.; tail long, at least 5 mm. longer than snout-vent length; nostril diameter usually 0.55 mm. or greater ...... *narisovalis*
   Size small, maximum snout-vent length 26 mm.; tail short, not more than 5 mm. longer than snout-vent length; nostril diameter usually less than 0.55 mm....... 6
6. Coloration pale; tail long, usually at least 40 caudal grooves; nostril proportionally smaller, generally less than one-half eye length; head dimly pitted .... *troglodytes*
   Coloration dark; tail shorter, less than 38 caudal grooves; nostril proportionally larger, usually at least one-half eye length; head pitted or not 7
7. Body and especially tail somewhat compressed; head dimly or not pitted; first toe shortest; fifth toe never absent .. *dubitus*
   Body and tail not compressed; head conspicuously pitted; fifth toe shortest, sometimes absent 8
8. Smaller, maximum snout-vent length, 22 mm.; snout narrow and somewhat pointed; maxillary teeth absent; toes not distinctly separated; fifth toe extremely reduced or absent .... *minutissimus*
   Larger, maximum snout-vent length, 25 mm.; snout broader and rounded; maxillary teeth present; toes distinctly separated at tips; fifth toe reduced but never absent .... *maxillabrochus*
9. Nostril smaller, largest diameter 0.40 mm. .... *pennatulus pennatulus*
   Nostril larger, smallest diameter 0.45 mm. .... *pennatulus narismagnus*

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A New Skink from Australia

Hymen Marx and William Hosmer

THE Chicago Natural History Museum has obtained from the junior author an outstanding Australian herpetological collection. This collection contains representative specimens of approximately 80 percent of the described species of reptiles and amphibians from that vast area. Among these specimens there is an undescribed skink named below. We take pleasure in naming this lizard after the late Karl P. Schmidt.

Rhodona karlschmidti, *sp. nov.*

Type.—Chicago Natural History Museum No. 97957, collected at Woodstock, about 23 miles south of Townsville, north Queensland, Australia, by A. Johnson in 1952.

Diagnosis.—A *Rhodona* with no forelimbs, relatively long monodactyl hindlimbs, 14 to 16 longitudinal narrow stripes around body and tail, and distinct frontoparietals and interparietal.

Description of type.—Body elongate; forelimbs absent; hindlimbs present, relatively long, equivalent in length to 6 adjacent scales, 3 mm. in length, 0.023 of total length and 0.044 of snout-vent length, monodactyl and clawed.

Snout cuneiform with angularly projecting labial edge. Eye small; lower eyelid with a large transparent disk. Three supraoculars; frontoparietals and interparietal distinct, the former widely separated and about one-half size of latter; parietals forming a suture behind interparietal; two pair of enlarged nuchals; two loreals; two preoculars; two postoculars; five upper labials, third being subocular; five lower labials; anal plate paired and enlarged; 16 scale rows around midbody; ear opening minute.

Total length 126 mm.; tail length 0.46 of total length. Tail complete and not regenerated.

Coloration (in alcohol): light brown having 14 dark brown longitudinal stripes running length of body and tail. The stripes are composed of short dashes and become obscure ventrally.

Paratypes.—Chicago Natural History Museum Nos. 97958 and 97741, same locality as the type and also collected by A. Johnson in 1952 and 1954 respectively.

No. 97958 differs from the type in snout-vent length (69 mm.), a regenerated tail, and 16 longitudinal stripes around body and tail. No. 97741 differs from the type in having a relatively longer hindlimb (0.040 of total length and 0.076 of snout-vent length), posterior loreal longitudinally divided, 18 scale rows at midbody, and the ventral stripes barely visible. Longman (1955:168) suggests that younger specimens can have relatively longer hindlimbs. No. 97741 has a total length of 100 mm., and the tail length is 0.48 of total length.

Comparisons.—*Rhodona karlschmidti* is similar to the following species of *Rhodona* in lacking forelimbs: *bipes* Fischer, 1882; *wilksoni* Parker, 1926; *lineata* Gray, 1839; *stylis* Mitchell, 1955; and *allanae* Longman, 1937.

R. bipes and *wilksoni* have didactyal hindlimbs, plus other characters which distinguish them from *karlschmidti*. Mitchell (1955:401) reports on 82 specimens of *stylis*, all having monodactyl hindlimbs. Loveridge (1934:372) records a specimen of *R. miopus* with "a rudimentry stump of a second toe." We find no other reference to intraspecific variation in the number of digits on the hindlimbs for *Rhodona*.

R. karlschmidti appears to be most closely related to *lineata*, *stylis*, and *allanae*, in having monodactyl hindlimbs and no forelimbs.

R. lineata differs from *karlschmidti* in having no preoculars, two small supraoculars, frontoparietals and interparietal fused into a single shield, and two middorsal stripes and two lateral bands.

R. stylis differs from *karlschmidti* in having a minute hindlimb (CNHM No. 97737: hindlimb 0.009 of total length and 0.015 of snout-vent length), color pattern with two broad lateral bands, a single loreal, and a relatively shorter tail (CNHM No. 97737: tail length 0.38 of total length).

R. allanae differs from *karlschmidti* in having the fourth upper labial subocular to the eye. Mitchell (1955) reports no intraspecific variation in this character for his 82 specimens of *stylis*. This species also differs from *karlschmidti* in having two frontonasals and six upper labials.

The following key will differentiate the known forms of *Rhodona* that completely lack forelimbs.

1. Hindlimbs didactyl 2
   Hindlimbs monodactyl 3
2. Frontoparietals and interparietal distinct .... *wilksoni*
   Frontoparietals and interparietal fused into a single shield .... *bipes*
3. Frontoparietals and interparietal distinct 4
   Frontoparietals and interparietal fused into a single shield .... *lineata*
4. Fourth upper labial below eye .. *allanae*
   Third upper labial below eye 5
5. Two dorsolateral longitudinal bands *stylis*
   Many narrow longitudinal dorsal and lateral stripes .... *karlschmidti*

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A New Frog of the Genus *Limnomedusa* from Colombia

DORIS M. COCHRAN AND COLEMAN J. GOIN

SOME time ago our friend, Mr. E. Ross Allen, presented us with a single specimen of a frog which we took to be a large *Leptodactylus.* When we were working together recently in Washington, we had occasion to re-examine this specimen and found that, while it is a leptodactylid, it apparently should not be assigned to the genus *Leptodactylus.* The combination of arciferal girdle, cylindrical sacral diapophyses, bony style on sternum, simple terminal phalanges, fingers and toes not dilated at tips, distinct tympanum, vertical pupil, webbed feet, and the presence of vomerine teeth, seems to place this species with Cope's leptodactylid genus *Limnomedusa.*

We are pleased to have the opportunity to dedicate this species to our late friend, Karl P. Schmidt, who was himself a student of this genus.

Limnomedusa schmidti, *sp. nov.*

Type—USNM 140245, adult male, collected in the forest near Leticia, Amazonas Comisaria, Colombia, during March, 1956, by E. Ross Allen.

Diagnosis—A large *Limnomedusa* with extensive webbing between the toes, and extensively developed dark mottlings on the ventral surface of the body and legs. From both *macroglossa* and *misionis,* it differs in being much larger (82.0 mm. snout-vent length as compared to 49.0 for a large female *misionis* and 58.6 for the largest *macroglossa* at hand).

From both of these forms it also differs in having the toes much more extensively webbed, the web extending to the base of the penultimate phalanx of the fourth toe and to the base of the ultimate phalanx of the other toes. In *schmidti* the vomerine tooth patches are slightly larger and more arched than in *macroglossa.* The most striking feature of *schmidti,* however, is its coloration—its very dark, nearly black, dorsal ground color, and the extensively developed blotching on the ventral surface of the body and limbs set it off at a glance.

Description—Vomerine teeth in two short, heavy, slightly arched series, between and on a line with the posterior margin of the internal nares; tongue broadly cordiform, its posterior margin free and with a very shallow notch; snout large, broadly rounded as seen from above, except for the tip which is somewhat truncate; tip of snout forming a broadly obtuse angle as seen in profile; upper jaw extending slightly beyond lower; nostrils nearer tip of snout than eye, separated by a distance about equal to their distance from the eye; internarial distance half again as great as interocular distance; eye

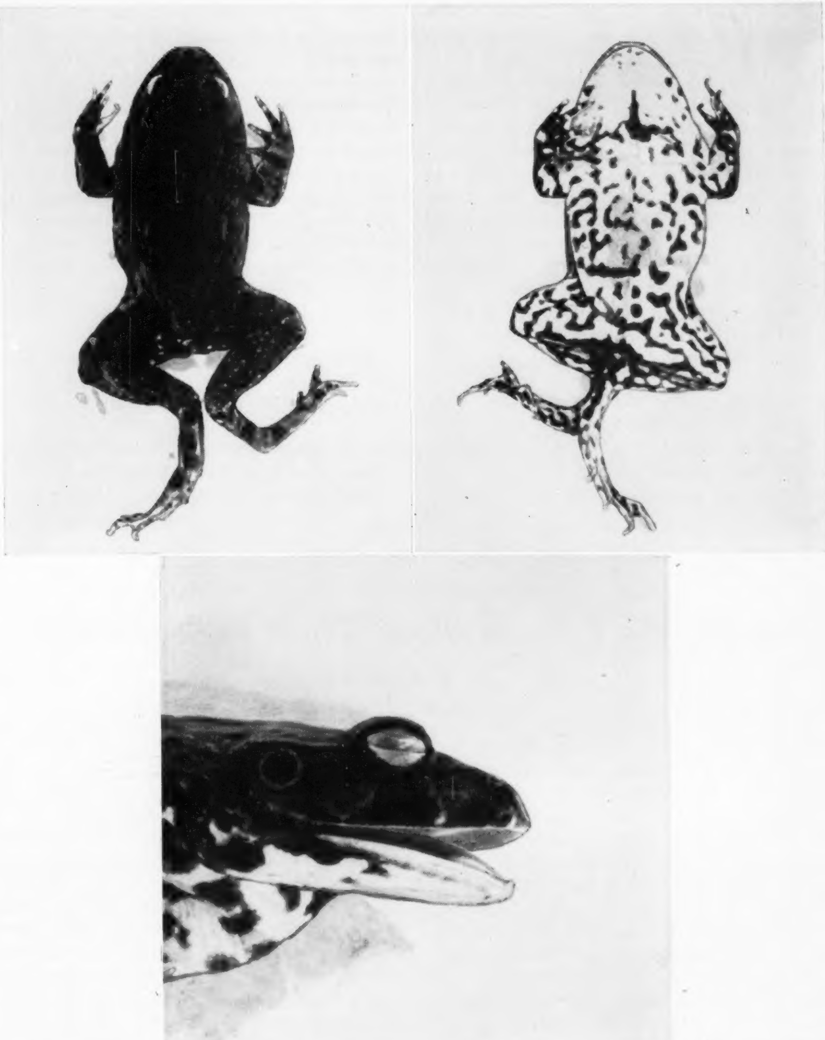

Fig. 1.—Type of *Limnomedusa schmidti*, USNM 140245, from Leticia, Colombia. *a*, dorsum (× ½); *b*, venter (× ½); *c*, lateral view of head (× 1).

prominent, its greatest diameter greater than distance from eye to nostril and nearly twice the interocular distance; canthus rostralis not prominent; loreal region slightly concave; tympanum moderate in size and very distinct, separated from eye by about one and one-half times its own diameter; greatest diameter of eye about twice that of tympanum. Fingers pointed, not webbed at base, the third the longest, the second and fourth subequal and extending to the base of the penultimate phalanx of the third; the terminal phalanx of the first finger strongly flexed; first finger slightly longer than second and fourth; no evident pollex rudiment. Toes slender, pointed, 4–3–5–2–1 in decreasing order of length, webbed to the base of the penultimate phalanx of the fourth toe

and the base of the ultimate phalanx of the others; a small outer and a larger inner metatarsal tubercle on each foot. Legs short, heel reaching posterior margin of eye when leg is pressed along side of body; elbow and knee just meeting when arm and leg are pressed along side; heels slightly overlapping when hind legs are held at right angles to body. Skin of dorsum rough and finely warty, particularly along sides; skin on snout and top of head smooth but upper eyelids covered with fine warts; a narrow glandular fold extending from posterior corner of eye to above tympanum where it turns down and is lost in the wartiness of the sides; no apparent subgular vocal pouch.

Dimensions (in mm.)—Snout-vent length, 82.0; head length, 30.0; head width, 34.6; crus, 32.3; shank, 36.2; pes, 62.3; hand, 20.4.

Color in alcohol—Top of head and dorsum very dark brownish gray; a light gray band on each side extending from below the eye to the anterior margin of tympanum; the region of the dorsum immediately behind the eyes just perceptibly paler than rest of dorsum; tops of arms and legs slightly paler than dorsum, with blotches of dark grayish black, these mottlings taking the form of indefinite cross bars on the thighs; ground color of ventral surface dirty white; a few dots of grayish black pigment under tip of chin; along the posterior borders of jaws, across the chest and belly, and under the arms extensive mottlings of dark grayish black, these mottlings becoming confluent on the under sides of the thighs and shanks so that they form definite reticulations.

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UNITED STATES NATIONAL MUSEUM, WASHINGTON, D. C., AND UNIVERSITY OF FLORIDA, GAINESVILLE, FLORIDA.

Foods of the Racer, *Coluber constrictor*, in Southern Illinois

W. D. KLIMSTRA

As is characteristic of much of food habits data for snakes, the dietary pattern of the racer, *Coluber constrictor,* is recorded in generalities. Quantitative studies are few and maximum numbers reported upon are small. Reports examined suggest that many writers presented authoritative statements which obviously were based on meager data of early writers.

Schmidt and Davis (1941) regarded the racers as indiscriminate feeders, with insects and small mammals contributing the bulk of the diet. Breckenridge (1944) identified a leopard frog, garter snake, two moths, and three crickets in four blue racers. Ortenburger (1928) found the food of 22 *flaviventris* to include largely insects (Orthoptera, Lepidoptera, and Coleoptera); small mammals showed the next highest percent utilization. Surface (1906), from an examination of the black racer, reported small mammals (38.0 percent), insects (28.5 percent), and birds (12.0 percent) as the most important foods. Uhler, *et al.* (1939) examined 16 stomachs of *constrictor* and recorded (by volume) reptiles (31.9 percent); small mammals (26.0 percent), birds (17.8 percent), insects (15.0 percent), and amphibians (9.4 percent). Cagle (1942) suggested that adult racers showed a wide variety in food items eaten; two species each of small mammals, snakes, and grasshoppers, were identified. Garman (1892) noted that this species of racer was a robber of bird nests as it climbed trees but it also preyed on frogs and field mice. Smith (1950) indicated that a wide variety of food was characteristic of the racer of Kansas, Conant (1951) classified the Ohio form as omnivorous, and Lueth (1949) emphasized the insect diet as well as toads, frogs, mammals, and other snakes for the Illinois racer. Pope (1947) suggested that a large part of the diet of *flaviventris* included small mammals, reptiles (snakes and lizards), frogs and toads, and birds including eggs; he considered much insect occurrence to be that of secondary ingestion.

Most specimens for this study were taken alive and killed upon reaching the laboratory where digestive tracts were removed and preserved in 10 percent formalin. Contents of the digestive tracts were removed by a forceful stream of water after the tracts had been slit lengthwise. For examination, these washed materials were placed with a small

quantity of water in medium-sized finger bowls for segregation and identification of food items. Reference collections of representative animals as well as prepared slides of hairs, feathers, fish and snake scales, and insect parts of representative southern Illinois forms were invaluable aids in the identification of foods utilized. Volumes were determined by water displacement and recorded in cubic centimeters. By relating total frequency of individual food items to number of digestive tracts containing food, average frequency was calculated.

The study herein reported represents an analysis of 137 digestive tracts of racers which were collected (1950–1957) in the vicinity of Carbondale, southern Illinois. The assistance of Mrs. Frances Newsome and Mr. John Oberheu in identifying food items, and of various personnel of the Cooperative Wildlife Research Laboratory in collecting snakes is gratefully acknowledged. This represents a contribution from Project No. 44.

The racer represents one of the more commonly occurring members of the Colubridae in the Mississippi Valley. The most utilized habitat in southern Illinois includes permanent vegetation of the uplands such as the grass and brush cover afforded by fencerows, idle areas, pastures, and meadows. Its arboreal and subterranean habits are evidenced by its utilization of trees and burrows. The ecological niches available to this snake in these environments are demonstrated clearly by the foods eaten.

Because the locality from which the specimens were collected was within the area of overlap of *flaviventris* and *priapus*, assignment of snakes examined to a specific subspecies was avoided.

Digestive tracts analyzed (Table 1) were available for March (7), April (24), May (30), June (24), July (17), August (14), September (12), and October (9). Twenty-two tracts which did not contain food were represented by three in March, three in July, six in August, six in September, and four in October. The lowest average volume of food was recorded for March, and the highest for June and October (Table 1); however, no significant difference can be indicated for June through October. The average volume per specimen showed an increase from a low in March to a peak in June, with a slight decrease occurring in July. This particular trend did not reflect the seasonal utilization which characterized the prairie king snake, *Lampropeltis calligaster*, (Klimstra, 1959), a species occupying a similar environment and with somewhat similar habits.

TABLE 1

NUMBERS OF DIGESTIVE TRACTS AND FOOD VOLUMES BY MONTHS FOR *Coluber constrictor*

Month	Food Volumes		Digestive Tracts		
	Total	Average	With Food	Empty	Total
March	100	25.0	4	3	7
April	1600	66.6	24	0	24
May	2699	89.9	30	0	30
June	2490	103.6	24	0	24
July	1300	92.8	14	3	17
August	800	100.0	8	6	14
September	600	100.0	6	6	12
October	515	103.0	5	4	9
Totals	10100	87.8	115	22	137

Analysis of the food habits (Fig. 1 and Table 2) showed that by volume insects ranked first (39.1 percent) followed by mammals (32.9 percent), amphibians (10.8 percent), reptiles (8.3 percent), birds (6.3 percent), and miscellaneous items (2.6 percent). Generally, percent frequency of occurrence and average frequency showed the same trend as percent volume.

Volumetrically over 80 percent of the insect material was contributed by Orthoptera, one of seven orders of insects occurring in the diet (Table 2). Hymenoptera, Diptera, and Arachnida unquestionably represented secondary ingestion (Neill and Allen, 1956). Immature forms (larvae) were recorded for only the Lepidoptera; all 10 occurrences were of this life cycle stage. Uhler, *et al.* (1939) reported similar findings. Among the Orthoptera, only two families, Gryllidae and Locustidae, were identified with the former being represented entirely by *Gryllus assimilis* and the latter *Melanoplus* spp. *Calosoma* sp. and *Harpalus* sp. were the most abundant forms of the Carabidae while *Canthon* sp., *Geotrupes* sp., and *Phyllophaga* spp. represented the Scarabaeidae.

Of the mammals, 80 percent were immature forms, frequently being young which were apparently captured at the nests both below and on the surface of the ground. By volume *Peromyscus* (45.3 percent) and *Microtus* (19.2 percent) yielded about 65 percent of the mammalian portion of the diet.

Cold-blooded vertebrates contributed

TABLE 2
QUALITATIVE AND QUANTITATIVE ANALYSIS OF FOOD ITEMS UTILIZED BY *Coluber constrictor*, MARCH–OCTOBER, SOUTHERN ILLINOIS
(115 Samples)

Food Items	Number of Samples In Which Item Occurred	Percent Frequency of Occurrence	Total Frequency	Average Frequency	Total Volume (Cu. Cent.)	Percent Total Volume
Insecta	*55*	*47.8*	*397*	*3.5*	*3950*	*39.1*
Orthoptera	68		312		3325	
Locustidae	40		194		2080	
Gryllidae	28		118		1245	
Coleoptera	9		36		205	
Unknown	3		17		100	
Carabidae	4		13		90	
Scarabaeidae	2		6		15	
Unidentified	6		17		164	
Lepidoptera	6		10		75	
Hemiptera	4		9		41	
Hymenoptera	2		1		21	
Homoptera	2		2		11	
Diptera	1		1		1	
Mammalia	*50*	*43.5*	*136*	*1.2*	*3324*	*32.9*
Peromyscus spp.	21		73		1505	
Microtus ochrogaster	14		19		640	
Sylvilagus floridanus	4		12		360	
Pitymys pinetorum	2		9		175	
Unidentified	8		8		148	
Scalopus aquaticus	2		3		140	
Rattus norvegicus	1		3		100	
Mus musculus	1		4		100	
Tamias striatus	1		2		60	
Synaptomys cooperi	2		2		41	
Amphibia	*15*	*13.0*	*40*	*0.3*	*1090*	*10.8*
Rana pipiens	8		16		530	
Bufo spp.	3		4		190	
Acris crepitans	3		8		120	
Rana catesbeiana	1		1		100	
Rana clamitans	1		2		80	
Rana palustris	1		2		80	
Hyla crucifer	2		4		30	
Pseudacris nigrita	1		3		20	
Reptilia	*14*	*12.2*	*16*	*0.1*	*836*	*8.3*
Lampropeltis calligaster	4		4		315	
Sceloporus undulatus	4		4		230	
Chrysemys picta	4		4		100	
Heterodon contortrix	1		1		100	
Unidentified	1		1		1	
Aves	*19*	*16.5*	*21*	*0.2*	*631*	*6.3*
Passeriformes	4		6		400	
Otocoris alpestris	1		1		100	
Sturnella magna	2		4		200	
Unidentified	15		15		231	
Miscellaneous	*17*	*14.8*	*32*	*0.3*	*263*	*2.6*
Arachnida	11					
Unidentified	12					

about 19 percent of the total food volume. The leopard frog (48.7 percent by volume) was the most commonly eaten member of amphibians, although seven other forms were utilized; no salamanders or tadpole stages were recorded. Reptilian foods were limited to two species of snakes and one species each of turtle and lizard; all were immature forms.

Identified avian food items were all nestlings and members of the Passeriformes; unidentified birds were suspected to represent this order also.

Trends in food utilization suggested environmental relationships. The major portion of this snake's diet reflected the potential food items expected to occupy the habitats frequented. This was displayed markedly by the occurrence in the diet of Orthoptera and Coleoptera, *Peromyscus* and *Microtus, Rana pipiens, Lampropeltis calligaster,* and the ground-inhabiting Passeriformes. The exceptions to these suggest something of the versatility of not only the predator but probably also the prey in utilizing environments slightly different from that to which each is often so rigidly assigned.

An analysis of the occurrence of food items in the diet (Fig. 1) suggested an intimate relationship with seasonal availability. This requires an interpretation of not only simple occurrence but also total numbers and acceptability (preference) of food items as food. The diet of this predator establishes mammals as the most prominent food in March and April, decreasing in importance through the remaining months. Insects, on the other hand, increased in the diet as mammals decreased. Cold-blooded vertebrates showed a pattern similar to that of insects but in considerably less magnitude. It is suggested then that insects were highly preferred compared to other foods. Although it might be reasoned that the use of insects was related simply to increased numbers, it must be remembered that all other forms were undergoing a rapid population increase as well. Locustidae were taken as early as March when their numbers were limited to only a few adults which successfully over-wintered. Conceivably, insects, because of their uncomparable reproduction in summer, were much more numerous than many prey forms and hence exceedingly

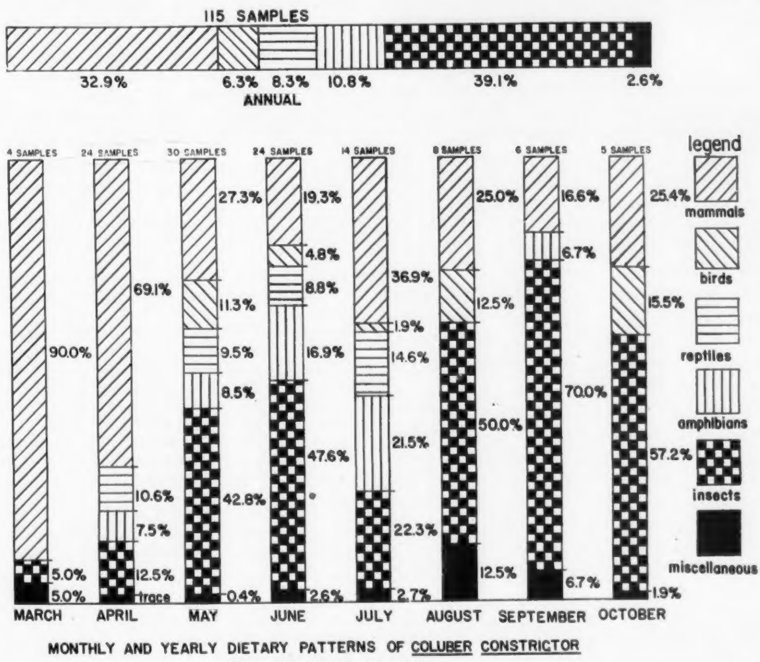

Fig. 1.—Monthly and yearly dietary patterns of *Coluber constrictor* from southern Illinois.

more available. However, this use of insects, which continued to increase monthly and by May showed extensive occurrence of Gryllidae, cannot be related merely to population increase due to reproduction, but strongly suggests that preference was a major determinant. Regardless of the ultimate analysis of these data, it was apparent that reproduction among prey species represented food "windfalls" as this predator's diet immediately reflected this availability aspect as evidenced by 80 percent of mammals being young-of-the-year and the seasonal occurrence of insects and cold-blooded vertebrates.

The diurnal feeding habit of this species was reflected in prey species utilized. The most obvious and distinctive in this respect was the occurrence of insects, specifically the Locustidae and Gryllidae, which show greatest activity during the daylight hours and when temperatures are highest. Field observations and laboratory analyses indicated that the racer fed largely during the middle segment of the daylight hours, this being most evident March through June and September through October. Feeding in July and August seemed to be earlier and later in the day, possibly to avoid the high temperatures at midday which characterize this period. There were a number of instances indicated by vertebrate foods utilized which also suggest diurnal feeding (Table 2), however, possible exceptions were also apparent.

Evidences of arboreal feeding were generally lacking as all identified food items suggested that feeding activity was restricted to terrestrial and subterranean sites (Table 2). Unidentified Passeriformes may have been an exception; however, these were believed to be largely terrestrial nesters. Of the 137 specimens collected, only six were taken from bushes or trees, suggesting that this form is more characteristic of *flaviventris* than the forest-inhabiting *priapus*.

The utilization of amphibians (Table 2) indicated that aquatic areas were frequented. In most instances these were probably farm ponds which were common in the area where snakes were collected. The absence of *Rana areolata* suggested that this snake was not a regular occupant of poorly drained or lowland areas where this frog occurred with considerable regularity.

Average food volumes per specimen showed little variation during May through October (Table 1), suggesting that availability was relatively constant during this period. Food volumes of March and April might be directly related to abundance of acceptable food. The number of empty tracts (36.5 percent) may have some correlation with cool temperatures and hibernation activities in March and October and inactivity and high temperatures (Klimstra, 1958) July through September. The extent of the effect of these factors on feeding habits needs further study as breeding and egg-laying may also influence feeding activity. Although empty digestive tracts showed evidence of being related to sexual maturity as adult females represented 74 percent of the tracts without food, only 4 percent of these adult females contained eggs and these were all recorded in July.

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Relationships in the *Pseudacris nigrita* Complex in Southwestern Georgia

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UNTIL 1940, only two races of the chorus frog, *Pseudacris nigrita* (Le Conte), were known from the coastal plain of the southeastern United States. One of these, *P. n. verrucosa* (Cope), is limited to peninsular Florida. The other, *P. n. nigrita,* is widely distributed in the southeastern coastal plain to the north of the peninsula.

A third form, the Piedmont-inhabiting *P. n. feriarum* (Baird), was reported from Florida by Carr (1940), who treated this form as a distinct species. He reported finding *feriarum* in 1935 "apparently common locally" along the Apalachicola River in Liberty County in western Florida. Carr was aware that *nigrita* also occurred in Liberty County, but reported no *nigrita-feriarum* integradation in his samples from this area. Presumably because of this, he assumed that the relationship between the two was at the species rather than the subspecies level. While Carr did not specifically discuss the spatial relationships of *nigrita* and *feriarum* in relation to their sympatry in Liberty County, he did differentiate between their Florida habitats locating *nigrita* in "pine flatwoods; high and mixed hammocks" and *feriarum* in "low hammock; river and creek floodplains and swamps." He felt that the major streams tributary to the Apalachicola River, the Flint and the Chattahoochie, had served as invasion pathways for *feriarum* and other Piedmont species and noted that their survival after invasion was probably dependent upon the Piedmont-like terrain found along the Apalachicola River in Florida.

Neill (1949) described intergradation between *nigrita* and *feriarum* some 250 miles to the northeast of Liberty County, Florida, along the fall line of eastern Georgia, and returned *feriarum* to its former status as a subspecies of *nigrita*.

Smith and Smith (1952) interpreted Neill's comments to mean that intergradation between *nigrita* and *feriarum* was known to occur in western Florida, and thus, that there was no geographic overlap of the two forms in this area.

Neill (1954) concluded that the Florida populations of *feriarum* were actually not of the *nigrita* complex at all but were close to *P. brachyphona*. His decision was based on the observation that Florida *feriarum* did not utter the trill characteristic of typical *feriarum,* but rather had a quacking call like *brachyphona*. Actually, our analysis of the voices of Florida specimens of *feriarum* and *nigrita* shows that they are of basically similar structure, and thus makes it unnecessary to remove Florida *feriarum* from the *nigrita* group to which it seems most closely related on general morphological grounds.

Recently, Schwartz (1957) reported a species level relationship between *feriarum* and *nigrita* in South Carolina comparable to that observed by Carr in western Florida. Schwartz found populations of the two forms, distinct in morphology and voice, existing side by side in situations within the coastal plain and along the fall line.

Schwartz also examined material from the area in which Neill had reported intergradation between *nigrita* and *feriarum* but found no evidence of a subspecific relationship. He felt that all of the specimens observed could be assigned without difficulty to one or the other of the two forms.

Consideration of the systematics of the over-all *nigrita* complex is beyond the scope of this paper, and the nomenclature employed should not be interpreted as reflecting taxonomic conclusions. We have attempted to contribute to an understanding of the biological relationships of two members of the *nigrita* complex in a relatively limited geopraphic area only. Certainly, relationships between the same or different members of the group in other areas may or may not be quite different from those observed by us.

Material developed in the course of the present study corroborates Carr's report of a species level relationship between *nigrita* and *feriarum* in Florida. In the Apalachicola drainage basin not only of western Florida, but also of southwestern Georgia, there are two forms of the *Pseudacris nigrita* complex, one *nigrita,* and the other very similar to, if not identical with, *feriarum*. The *feriarum* form differs from *nigrita* in having a broader head and less pointed snout, longer posterior legs, and a dark triangle or no marking between the eyes; dark longitudinal stripes may be suggested in the dorsal pattern, but ran-

domly dispersed blotches, flecks, or even a unicolored pattern are more characteristic (Fig. 1). By comparison, *nigrita* usually exhibits three more or less broken, longitudinal stripes, the middle one running anteriorly between the eyes and out along the snout. Tibial bands of *feriarum* are not so dark as those of *nigrita*, and the lighter areas between them are broader than the bands themselves or about as broad. The pinkish ground color noted by Carr is striking and typical and, incidentally, more noticeable than in Piedmont *feriarum*. The distinctness of the *nigrita* and *feriarum* populations in the area is such that, if one knew only those populations in this situation, he would have to refer them to different species. Further, we have seen no indication of intergradation of these two forms at the population level in this general area.

While Carr's original report was based on material from northwestern Florida, the present study was carried out some fifty miles to the northeast in the Flint River basin of southwestern Georgia.

Ecological Distribution

The observations and specimens relating specifically to this study were accumulated between early January and late April of 1950 and in March, 1958, in Calhoun, Baker, and Mitchell counties, Georgia (Fig. 2). The populations most intensively studied occupied a limited area of the Flint River floodplain and adjacent higher ground on either side of the river near the town of Newton.

The ranges of *nigrita* and *feriarum* clearly overlap within the Apalachicola drainage basin. However, breeding pools of the two forms usually occur in different ecological

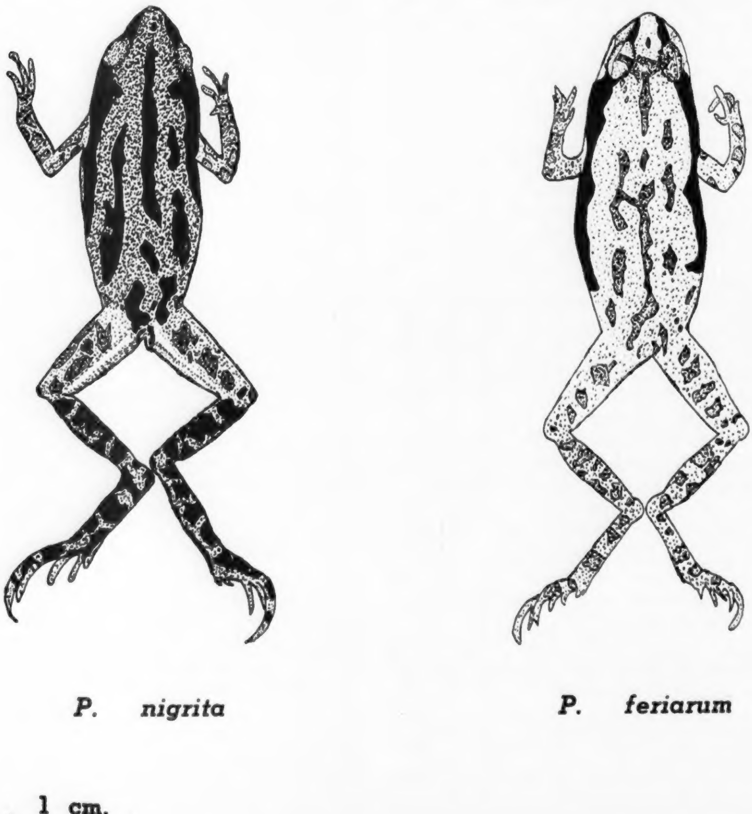

Fig. 1.—Dorsal aspect of *Pseudacris nigrita* and *P. feriarum* from southwestern Georgia near Newton, showing differences in head shape and dorsal color pattern.

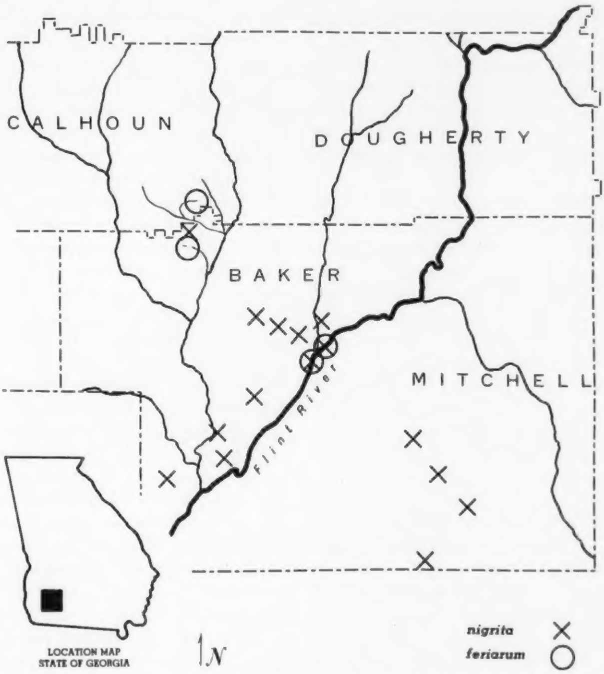

Fig. 2.—Map of portion of southwestern Georgia showing collection localities of *Pseudacris nigrita* and *P. feriarum*.

situations. Without exception, breeding choruses of *feriarum* were found to lie within or immediately adjacent to the floodplains of permanent or intermittently flowing streams. Such choruses usually occupied temporary floodplain pools or shallow temporarily flooded drainage ways. By contrast, *nigrita* choruses were widely scattered throughout the uplands, and only occasionally were heard within stream floodplains. Breeding choruses of this form were observed in a variety of flooded situations including temporary grassy pools in forest, old field and pasture habitats, the grassy margins of ponds, and shallow, grassy parts of small streams. On several occasions, *nigrita* and *feriarum* were found together in chorus within pools lying near the junction of floodplain and upland habitats.

Morphological Overlap

Of 109 specimens of both forms examined, including 63 examples of *feriarum* and 42 of *nigrita*, only four could not be allocated readily to one form or the other on the basis of the more objectively determinable morphological characters (Fig. 1). While head shape of the two forms is clearly different in the majority of specimens, a few suggested intermediacy. In such cases species determination was based on the other three characters. It is appreciated that these characters are not of value in all areas in the diagnosis of *nigrita* and *feriarum* as presently defined.

The four specimens mentioned above which could not be easily identified exhibited various combinations of *nigrita* and *feriarum* characters and are believed to represent genetically intermediate specimens. A report considering the evolutionary implications of hybridization between these two forms is in preparation by Crenshaw.

Two additional character differences, relative head width and length of tibia, were found to be of some value in the allocation of questionable specimens after statistical comparison of the two populations. The head width measurement, expressed as a percentage of snout to vent length, was taken with a vernier caliper at the level of the angle of the jaws. This measurement did not prove to be as useful in the diagnosis of individual specimens as total head shape.

The mean relative head width of *nigrita* was 31.6 (± .42) percent of snout-vent length (range 29.9–34.2 percent). By comparison, the mean relative head width of *feriarum* was 33.8 (± .37) percent of snout-vent length (range 31.3–37.0 percent). The difference between these means is statistically significant (t value 3.55).

Length of tibia, also considered as a percentage of snout-vent length, was taken with a vernier caliper as the overall length of the tibial segment with femur and foot at right angles to the tibia. When tested for symmetry, the frequency distribution of percentage values for *nigrita* differs significantly from a normal distribution (t value 10.7). The frequency distribution of percentage values for *feriarum* does not differ significantly from a normal distribution, however the t value determined (2.1) may well reflect real asymmetry.

The apparent asymmetry in both populations is due to a skewing of each toward the other, thus effectively demonstrating a basic difference in the two. The means of the two populations are closer together than the modes, and the standard deviation of each is increased in response to the skew. While it is not strictly proper to employ statistical methods based on normal frequency distribution in the comparison of asymmetrical curves, in the present case we have done so for purely descriptive purposes. Tibial length was found to range between 44.2 and 53.9 percent of snout-vent length (mean 48.5 ± .26; mode 47.5 percent) in *nigrita*, and between 46.4 and 56.2 percent (mean 50.8 ± .25; mode 51.5 percent) in *feriarum*.

There may be some slight sexual dimorphism in either or both of these characters, but our samples are not sufficiently large to demonstrate that such is the case.

Discussion

Isolating mechanisms.—In view of the strong tendency to distinctness of these two forms in nature, it is evident that a reproductive barrier of one kind or another is effective in the maintenance of their genetic integrity. It seems probable that this reproductive barrier is a complex combination of several factors, none completely effective, but each acting to lessen the degree of interbreeding.

It has been suggested by Neill (1949) that altitudinal isolation operates to maintain allopatry in the *nigrita* and *feriarum* populations of the Apalachicola drainage basin. He felt that the relatively high terrain along the Apalachicola River and its tributaries might be avoided by the lowland *nigrita* thus permitting inhabitation exclusively by the typically Piedmont *feriarum*. However, it has already been pointed out that there is extensive overlap of the two forms in a broad geographic sense and even limited ecological overlap in local areas. More important, it is emphasized that *feriarum* is by no means limited to higher altitudes. Most of the coastal plain specimens of *feriarum* thus far collected have been taken at altitudes of between 50 and 200 feet above sea level, well within the known altitudinal range of *nigrita*. Paradoxically, in a given coastal plain locality the floodplain-inhabiting *feriarum* usually occurs at slightly lower altitudes than the upland *nigrita*.

Similarly, temporal isolation is probably of no importance in preventing the genetic intermixture of *nigrita* and *feriarum*. The breeding seasons of the two forms are virtually identical. Both appear to be closely correlated with the occurrence of winter rain, and certainly the major part of breeding activity did occur for both at the same time in the early months of 1950. Schwartz (*op. cit.*) also found seasonal overlap in choruses of the two forms, but he observed that the major choruses of *feriarum* occurred early and had waned by the time the major choruses of *nigrita* began. It is possible that a similar situation obtains in southwestern Georgia during warm, rainy winters.

The first observed winter chorus of *feriarum*, following the first rain worthy of mention for several months, occurred on January 11, in 1950. Although the first chorus of *nigrita*, positively identified as such, was not recorded until a month later, on February 9, a breeding chorus of one of the two forms had been recorded on January 13, in an upland area subsequently found to contain only *nigrita*.

In 1950, the last chorus of positively identified *feriarum* was recorded on April 4, while the last chorus of *nigrita* was recorded on April 30, the latter in western Florida. Again, a single calling individual, tentatively identified as *feriarum*, was recorded on April 27. The very large choruses of both forms were all recorded between February 9, and April 4.

Spatial isolation apparently operates at two levels in preventing hybridization: breeding pool isolation and intra-pool segregation. It has already been implied that

the greater part of the breeding pools occupied by *nigrita* lie in the uplands, well removed from *feriarum* populations. Thus, the vast majority of the *nigrita* population in areas where both forms occur is physically removed from contact with *feriarum* by its ecological adaptation to upland breeding pools. This leaves only a fringe of the *nigrita* population to come into contact with *feriarum* at the edges of, or rarely within, floodplains. Ecological barriers appear to maintain most floodplain pools as the breeding sites exclusively of *feriarum*.

Considering the entire populations of *nigrita* and *feriarum* in the Apalachicola drainage basin, interbreeding would be limited to those individuals breeding in pools occupied by both forms. This would include a minority of the *feriarum* population, an even smaller proportion of the *nigrita* individuals.

Even within a mixed breeding pool, ecological factors operate to separate the *nigrita* and *feriarum* components for the most part. Calling males and amplexing pairs of *nigrita* were usually taken in the grassy portions of pool margins, and were always relatively well concealed. By contrast, calling and amplexing examples of *feriarum* were usually found clinging to leaves and twigs in the non-grassy portions of pools, from margin to center. Usually they were anything but well concealed. For such intra-pool segregation to be effective as a mechanism of reproductive isolation, it would seem to be necessary that females be able to differentiate between the calls of the two forms present, and orient and move toward calling males of their own kind.

Differences in the mating calls of the two kinds of frogs are readily apparent to the human ear. Tape recordings of the calls of 13 *feriarum* and 10 *nigrita* were made on the nights of March 6, and 7, 1958, near Newton, Baker County, Georgia. Recordings of five of the *feriarum* were made in a mixed population of the two species in a floodplain rainpool, one was made in an unmixed population in a pool in the town of Newton, six were made in an unmixed population in a floodplain rainpool, and one was made in a mixed population in which *nigrita* predominated in an upland pool at the border of the floodplain. Six of the recordings of *nigrita* were made in this same upland pool, and four made in a mixed population in a floodplain rainpool.

Sound spectrograms of the calls have been made and provide an objective basis for comparison of the calls of the two species. Measurements of the dominant frequency, pulses per second and duration in the 23 individuals are shown graphically in Fig. 3. The individuals labeled *nigrita* showed the earlier mentioned morphological characteristics of that species, while those labeled *feriarum* showed the characteristics of that species. It is readily apparent from the graph that the two species populations in this area of sympatry differ in all of the three attributes of call that were measured. Of the three, however, the difference in repetition rate (pulses per second) is the greatest, and there is no overlap of the two samples in this character.

The pulse rate is almost four times as great in the calls of *feriarum* as it is in the calls of *nigrita*. The mean of the means for the calls of the 13 *feriarum* is 43 pulses per second; that for the 10 *nigrita* is only 11 pulses per second. The most slowly pulsed individual call recorded for any *feriarum* had a rate of 35 pulses per second, and the average for this individual was 37. The most rapidly pulsed individual call of any *nigrita* had a rate of only 13 pulses per second. In both species the pulse rate slows at about the middle of the call (Fig. 4). This is much more apparent in *nigrita* than in *feriarum* because of the much greater interval between notes in the former. Difference in pulse rate thus seems to be the most important aspect of the call in relation to species discrimination because of the striking difference between the two populations and the lack of overlap in this character.

The two populations also differ in duration and in frequency of the call, but there is some overlap in both. The *nigrita* frogs tend to have a longer call than *feriarum*. The mean of the means of individual calls of the 10 *nigrita* is 0.82 second. The shortest individual call recorded was 0.45, and the longest was 1.05 second in length. The mean of the means of the individual calls of the 13 *feriarum* is 0.62 second. The shortest individual call recorded for this species was 0.37, and the longest was 0.91 second. The dominant frequency (mid-point of the dominant frequency band) is generally higher in *nigrita* than in *feriarum*. The mean for the 10 *nigrita*, measured in one call per individual, is 3,212 cps., that of the 13 *feriarum* is 2,752 cps. There was only slight overlap in this character among the 23 individuals recorded. The *feriarum* with the highest dominant frequency had one of 3,000 cps.

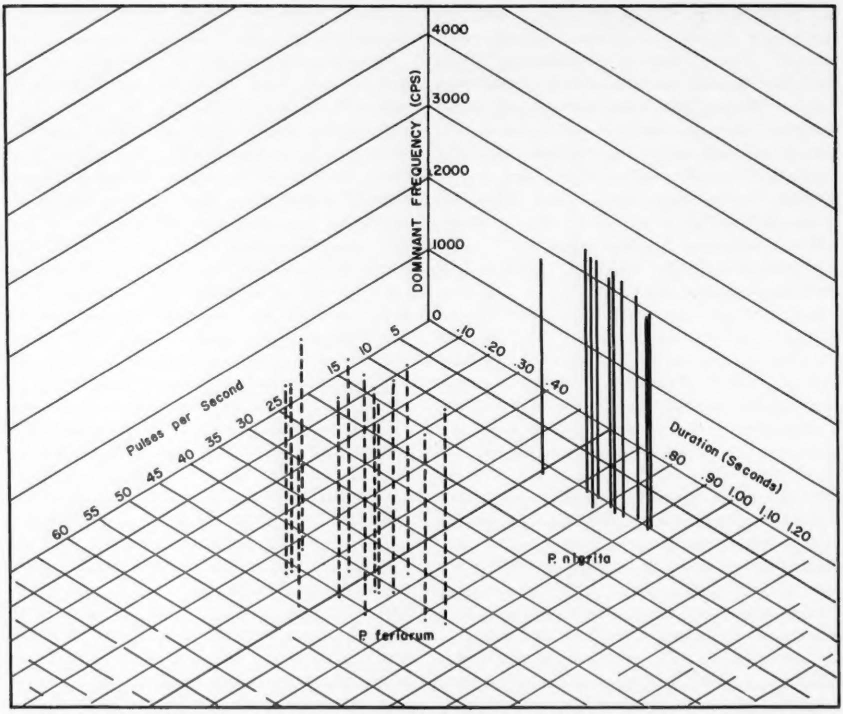

Fig. 3.—Three dimensional graph showing variation in three attributes of the call of *Pseudacris nigrita* and *P. feriarum* from the vicinity of Newton, Baker County, Georgia. Each vertical line represents the means for an individual frog (usually 6 calls). Pulses per second and duration at base of vertical line can be read directly on intersecting base lines. Dominant frequency is represented by height of vertical line; this cannot be read directly, but must be compared with scale in center, background.

while the *nigrita* with the lowest frequency had one of 2,950 cps.

The prominent differences in mating call, particularly in pulse rate, along with general ecological and intra-pool segregation, are indicated as being probably the most significant factors maintaining the two populations as largely separate breeding systems. Infrequent hybrids may be explained as the result of mistakes when a female moving toward a calling male of her own kind might pass too close to a male of the other kind and be taken in amplexus. If, as has been shown for other species (Blair, 1958), discrimination rests with the female, it should be only rarely that a female would be clasped by a male of the "wrong" species.

Summary

Studies carried out in the early months of 1950 and in March of 1958 in southwestern Georgia and western Florida confirm that two forms of the *Pseudacris nigrita* complex, *P. nigrita* and *P. feriarum*, occur in the area and they there exhibit the biological relationships characteristic of distinct species.

Morphologically the two species may be differentiated with few exceptions on the basis of head, body, and tibial color pattern and head shape. There are also significant differences in head width and tibial length relative to snout-vent length.

For the most part, breeding choruses of the two occur in different ecological situations, *feriarum* being limited to pools lying within or adjacent to the floodplains of streams, *nigrita* tending to occupy more upland habitats. Breeding choruses containing both species were found in pools at the junction of floodplain and upland habitats. Within such mixed breeding choruses, *nigrita* and *feriarum* components tended to

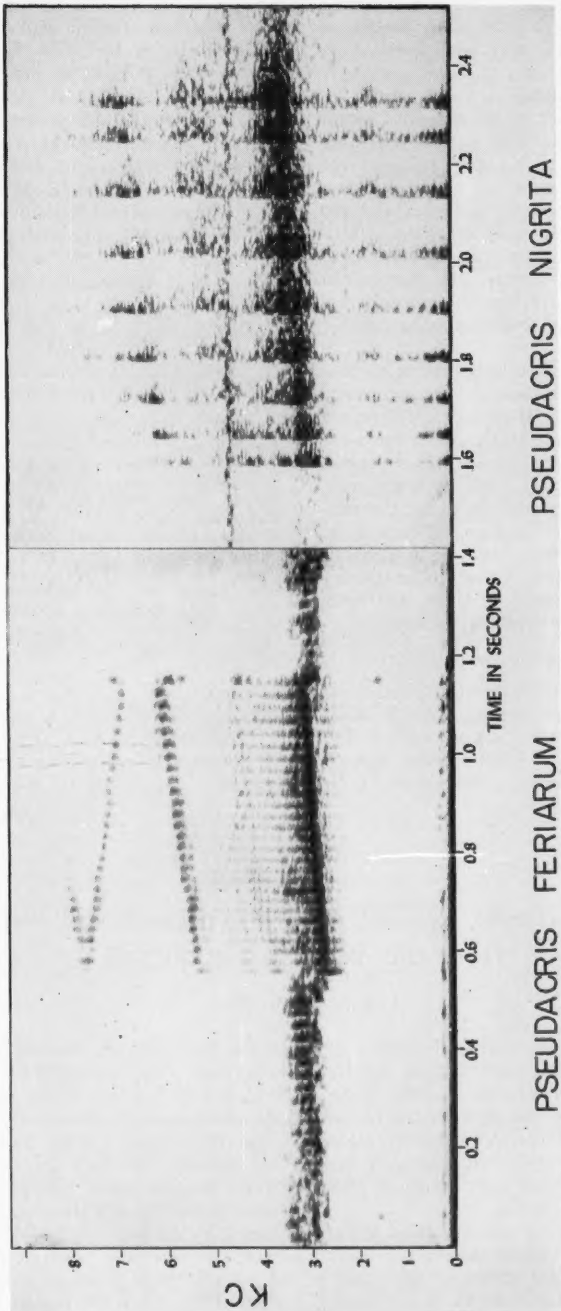

Fig. 4.—Sound spectrograms of one call of *Pseudacris feriarum* (left) with background of other calls and one call of *P. nigrita* with faint background of other calls. Both recorded near Newton, Baker County, Georgia. The calls are basically similar in structure but differ greatly in pulse rate.

occur in different areas, the former being usually well concealed in grassy situations, the latter occupying more open sites among dead leaves and twigs.

Breeding calls of *nigrita* and *feriarum* are readily distinguished by the observer. Sound spectrograms of the calls indicate that the two species differ with respect to dominant frequency, duration of call and pulse rate. The dominant frequency is higher and the call duration longer in *nigrita* than in *feriarum,* but some overlap was found in both characteristics. No overlap was observed in pulse rate, which averages about four times as great in calls of *feriarum* as in calls of *nigrita.*

Mechanisms apparently operating to promote reproductive isolation of the two breeding systems include: (1) ecological differences in breeding pool site resulting for the most part in single species choruses, (2) ecological segregation of the *nigrita* and *feriarum* components even in mixed breeding choruses and (3) conspicuous species differences in pulse rate and other aspects of the mating call which would make it possible for females to orient toward males of their own kind even within mixed breeding choruses.

Acknowledgements

For making available specimens and data, for reading the manuscript, and for assistance in many ways, we are grateful to Dr. R. E. Bellamy, U. S. Public Health Service Encephalitis Laboratory, Bakersfield, California, and Dr. Charles F. Walker, University of Michigan Museum of Zoology. We are also indebted to Dr. Don W. Hayne for suggesting the method of presentation employed in Figure 3 and to Mr. Milton Hopkins for invaluable assistance in the field.

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Parahollardia schmidti, a New Triacanthodid Fish from the Western Caribbean

Loren P. Woods

DURING an exploratory fishing cruise of the U. S. Fish and Wildlife Service M/V *Oregon* to trawl in the vicinity of the submerged banks of the Western Caribbean Sea in August and September of 1957, eight specimens of an undescribed species of the family Triacanthodidae were captured. This species is described below.

In the same general area but from different localities and various depths the trawl netted two additional species of the family Triacanthodidae, 4 specimens of *Hollardia hollardi* Poey (*Oregon* Stations 1882, depth 160 fathoms; 1883, depth 200 f.; 1887, depth 300 f.; and 1923, depth 275 f.) and one specimen of *Johnsonina eriomma* Myers (*Oregon* Station 1903, depth 150 f.). Two specimens of *H. hollardi* from deep water (B.O.C. 540, 543, no locality given but probably near Glover Reef off British Honduras) have been reported by Breder, 1927. *Johnsonina eriomma* is known from north of Puerto Rico and off the north coast of Cuba (*Oregon* Stations 1342, depth 280 f., and 1343, depth

250 f.) but has not previously been reported in the Caribbean.

Parahollardia schmidti, *sp. nov.*

Holotype.—USNM 185607, *Oregon* Station 1868, Western Caribbean Sea, Latitude 16°36′ North; Longitude 82°37′ West, 175 fathoms, 40-foot flat trawl, 21 August 1957, standard length 67.2 mm.

Paratypes.—CNHM 64391, *Oregon* Station 1868, 5 specimens, standard length 50.2–68.5 mm., CNHM 64390, *Oregon* Station 1867, Latitude 16°38′ North; Longitude 82°43′ West, 140 f., 40-foot flat trawl, 21 August 1957, 1 specimen, standard length 48.5 mm.; CNHM 64392, *Oregon* Station 1895, Latitude 14°40′ North; Longitude 81°25′ West, 300 f., 40-foot flat trawl, 25 August 1957, 1 specimen, standard length 60.2 mm.

Diagnosis.—Dorsal rays VI, 15; anal rays 13; teeth in upper jaw 8–13, in lower 12–19; an inner row of teeth present in both upper and lower jaws; scales of sides with 4 or 5 slender spines on each scale; angle of snout profile with horizontal axis of body 35°–39°; ventral extent of gill opening to middle of pectoral base; upper side with 3 or 4 faint lengthwise stripes.

Description.—(The counts and proportions of the holotype are given first followed by the range of variation noted in the paratypes in parentheses. All proportions are in standard length).

Dorsal rays VI-15 (VI-15); anal rays 13 (13); pectoral rays 13/13 (13/13–13/14); pelvic I, 1/I, 1 (I, 1–I,2); gill rakers on first gill arch 13 (12–17); teeth in upper jaw 13 (8–13), teeth in lower jaw 19 (12–19), teeth on palate behind main row 4 (0–4), teeth behind main row in lower jaw 2 (1–3).

Length of head 2.52 (2.48–2.60), greatest depth of body 2.07 (1.72–2.02), snout 5.95 (5.48–6.52), eye 6.17 (5.74–6.69), interorbital 7.16 (7.72–9.79), gill opening 16.0 (12.9–15.2), width of pectoral base 16.8 (12.4–15.7), depth of caudal peduncle 10.3 (10.0–12.7), length of caudal peduncle 5.6 (5.48–6.08), tip of snout to origin of dorsal fin 2.10 (1.98–2.11),

TABLE I

COUNTS ON THE WESTERN ATLANTIC SPECIES OF TRIACANTHODIDAE

Species	Dorsal*					Anal*			Pectoral						Gill rakers on first gill arch												
	VI	VII	15	16	17	13	14	15	12/13	13/13	13/14	14/14	14/15	15/15	12	13	14	15	16	17	18	19	20	21	22	23	24
Parahollardia schmidti	7		7			7				5	2				1	1	1	2	2	1							
Parahollardia lineatus	8	2	3	7		1	9		1	8						2	1	3	1								
Hollardia hollardi	7	1	1	1	6		1	7			2	4		2						2	4						
Johnsonina eriomma	11		11			11					1	8	1											4	2	2	2

Teeth of Outer Row

	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
P. schmidti																			
Upper	1	..	..	3	..	2	1												
Lower				1	1	..	1	1	1	..	..	2							
P. lineatus																			
Upper				1	2	4	..	1											
Lower							1	2	4	..	1								
H. hollardi																			
Upper						1	..	..	3	2	..	..	1	1					
Lower										1	1	2	..	1	1	1	..	1	
J. eriomma																			
Upper																			
Lower																			

	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
P. schmidti																			
Upper																			
Lower																			
P. lineatus																			
Upper																			
Lower																			
H. hollardi																			
Upper																			
Lower																			
J. eriomma																			
Upper		1	..	3	1	1	..	1	1	..	..	1	..	..	1				
Lower			1	1	..	..	1	..	..	2	..	..	1	2	..	..	..	..	1

* Contrary to usual practice, I have counted the last unbranched ray as one since this ray always has a separate base and is occasionally branched itself.

origin of dorsal to base of caudal fin 1.43 (1.44–1.51), length of first dorsal spine 2.99 (2.87–3.26), length of pectoral fin 5.43 (5.69–6.39), length of pelvic spine 3.54 (3.0–4.02), length of middle caudal rays 3.74 (2.59–3.94).

First dorsal spine inserted anterior to vertical from gill opening, spine only slightly longer than pelvic spine; dorsal and pelvic spines with denticles almost to tip; pelvis narrow and compressed so bases of pelvic spines are in contact when depressed; a slit behind 4th gill arch; pseudobranchiae covering upper half of operculum; 4 or 5 denticles on each scale.

Color.—Faded in preservative to light tan with four faint lengthwise stripes on upper sides, a dark stripe on midline of nape, tip of upper lip black. Color in life not known. Lengthwise stripes distributed as follows: upper, along base of dorsal fin from origin of spinous dorsal to middle of soft dorsal, the second, beginning midway on nape between first spine and upper rim of orbit and running posteriorly to base of last dorsal rays (in some specimens a narrow incomplete stripe between these two). Fourth stripe broader, just below the 3 described above. Lining of gill cavity black.

Remarks.—The genus *Parahollardia* (type species, *Triacanthodes lineatus* Longley and Hildebrand) was established by Fraser-Brunner, 1941. He gave the jaw teeth as 10 upper and 12 lower *with an inner series.* For *Hollardia* the jaw teeth were given as 14 upper and 16 lower *with no inner series.* I find *P. lineatus* to have 11–15 teeth in the upper jaw with an inner series of 2–5, and 15–18 teeth in the lower jaw with an inner series of 2–5. In 8 specimens of *Hollardia hollardi* I count 13–21 upper and 17–25 lower teeth. The number of teeth does not serve to distinguish these genera.

The genera are distinct in several other respects. *Parahollardia* has the dorsal spine inserted anterior to the gill opening whereas in *Hollardia* it is over or posterior to the upper edge of the gill opening; *Parahollardia* has 4 to 7 fine spines on most of the lateral scales whereas *Hollardia* has only 1 or 2 well-developed spines on each scale; these spines are coarser than are those of *Parahollardia.* As described by Fraser-Brunner the pelvis of *Hollardia* is narrower than in *Triacanthodes* or *Johnsonina* but is a little broader than in *Parahollardia.* When depressed the inner bases of the spines are in

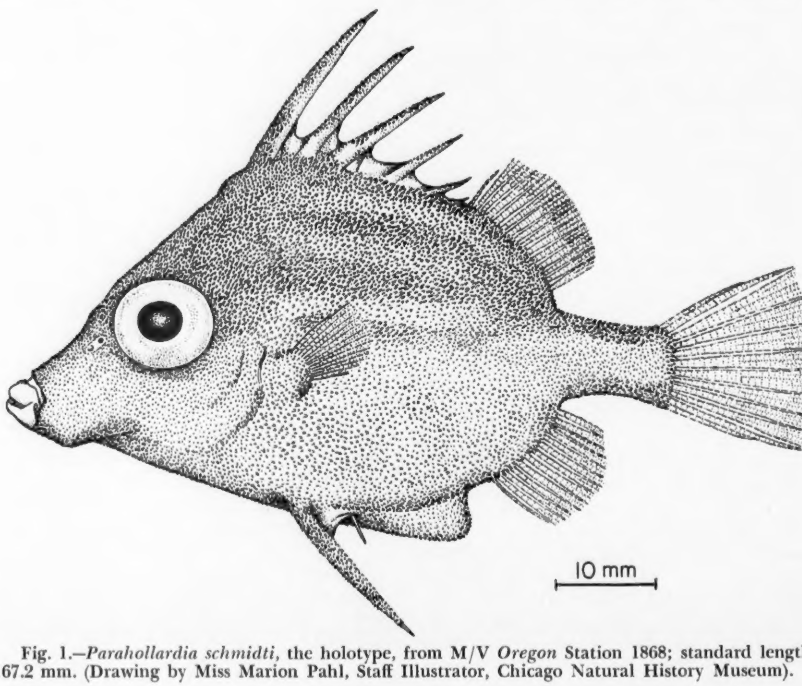

Fig. 1.—*Parahollardia schmidti*, the holotype, from M/V *Oregon* Station 1868; standard length 67.2 mm. (Drawing by Miss Marion Pahl, Staff Illustrator, Chicago Natural History Museum).

contact in both *P. lineatus* and *P. schmidti* but in *Hollardia* there is a definite space between the basal parts of these spines.

In the characters listed above and many others, *Parahollardia schmidti* resembles *P. lineatus*. The two species may be distinguished as follows: *schmidti* has 13 anal rays, *lineatus* has 14 (one specimen out of 10 with 13); the spines on most of the lateral scales are 4 or 5 in *schmidti* and 6 or 7 in *lineatus;* the angle of snout profile with horizontal axis of body is 35°–39° in *schmidti* and 40°–46° in *lineatus*. The predorsal profile is steeper in *lineatus* in specimens of the same size. This is because the ridge of the nape in *lineatus* extends farther forward between the eyes. This same ridge causes the interorbital over the anterior part of the eye to be strongly convex in *lineatus* whereas in *schmidti* this area is flat or even slightly concave. The supraorbital rims are more prominent in *schmidti* than in *lineatus*. The gill opening extends ventrally to level of lower base of pectoral fin in *lineatus* but only to the middle of pectoral base in *schmidti*; the dorsal spine is only slightly longer than the pelvic in *schmidti* (1.04–1.18) but in *lineatus* the dorsal spine is more slender and proportionally longer than the pelvic (1.26–1.59). There is a difference also in color pattern. *Parahollardia schmidti* has four lengthwise stripes on the upper side whereas *P. lineatus* has 5 or 6 stripes over the same part of the body with 3 or 4 additional stripes on the lower side that are not evident in *schmidti*.

This species is named in honor of Dr. Karl P. Schmidt.

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Descriptions of Newly Discovered Western Atlantic Specimens of *Diceratias bispinosus* Günther and *Paroneirodes wedli* (Pietschmann)

Marion Grey

THE little known ceratioid family Diceratiidae contains two genera, *Diceratias* Günther and *Paroneirodes* Alcock, and possibly three species. A third genus with one species, *Laevoceratias liparis* Parr, based on a single male specimen, has also been included in the family and is the only species reported from the western Atlantic. It is therefore of interest that specimens of both *Diceratias* and *Paroneirodes,* of which only females are known, have been caught recently in the western Atlantic during the explorations of the United States Fish and Wildlife Service research vessel *Oregon*. Examination of the two specimens described below has disclosed a few hitherto unknown characters. The upper pharyngeal teeth are in two groups in both species, and on both also there is a large subcutaneous structure of unknown function on each side of the outer surface of the lower jaw. The skin of *P. wedli* is spinulose, not naked as has been assumed. And finally, *D. bispinosus* has one or two small papillae on the illicium stem, well below the esca.

Through the kindness of Miss Ethelwynn Trewavas the following information on the type specimen of *D. bispinosus,* which is in the collection of the British Museum, is made available.

"It has upper pharyngeal teeth in two groups on each side and no lower pharyngeal teeth. The second cephalic ray is a tag-like papilla with a black tip ending in a white-

lipped pore. Its bony ray has not been exposed, but the fibrous tissue under the skin at the base of the papilla seems to have a rigid core, which does not extend beyond the surface of the skin."

"About half-way up the stem of the illicium is a pair of black-tipped papillae which must at some time have dried and stuck to the skin of the stem."

"There is nothing corresponding to your 'stout tentacle' on the lower jaw."

Although the type specimen of *D. bispinosus* shows no evidence of it, the subcutaneous structure on the outside of the lower jaw is probably present. In our specimen of *P. wedli,* which is in excellent condition, this structure was not discernible until the skin covering it had been removed.

I wish to express my appreciation to Miss Trewavas; and to Dr. E. Bertelsen also, for helpful comments. Figure 1 was drawn by Mr. John Pfiffner, Staff Artist, Chicago Natural History Museum.

Diceratias bispinosus Günther

One specimen, total length *ca.* 178.5 mm., standard length *ca.* 130 mm. *Oregon* Station 2011, 07° 46′ N., 54° 36′ W., Atlantic off northern South America, 7 November 1957, 400 fathoms (732 meters).

Fin rays: dorsal 6, anal 4, pectoral 13, caudal 9. Branchiostegal rays 6. Measurements in millimeters: depth 81; peduncle depth 18; greatest width of head 49.5; width at pectoral base *ca.* 39; width at peduncle 7; length of head *ca.* 77; distance between tip of sphenotic spine and symphysis of upper jaw *ca.* 35.5; upper jaw 46.5; lower jaw 48; width of vomer 18.5; illicium (including esca but not basal bone) 41.5; basal bone 3.5; esca 6.5; distance between last dorsal ray and base of middle caudal rays 14, between last anal ray and base of middle caudal rays 13; longest dorsal ray 19; longest anal ray 15; longest caudal ray 48.5.

Entire head and body, including illicium and esca, covered with close-set, minute spines. Tail short, compressed, rest of body and head somewhat bulbous. Skin torn off lower jaw and underside of head but most of it still present, and capable of being pushed into normal position. Peduncle of pectoral fin short. Caudal fin entirely free of skin. No evidence of lateral-line system visible.

Sphenotic spines large. Eye very small, subcutaneous, 15 mm. behind maxillary, 7 or 8 mm. in front of base of sphenotic spine. Nasal tubes relatively conspicuous, close to maxillary, about 9 mm. in front of eye. Cleft of mouth wide, reaching beyond eye. On outer surface of lower jaw on each side, 21 mm. behind the symphysis, a stout tentacle, or gland(?), attached only at its base, its length *ca.* 14 mm., undoubtedly concealed

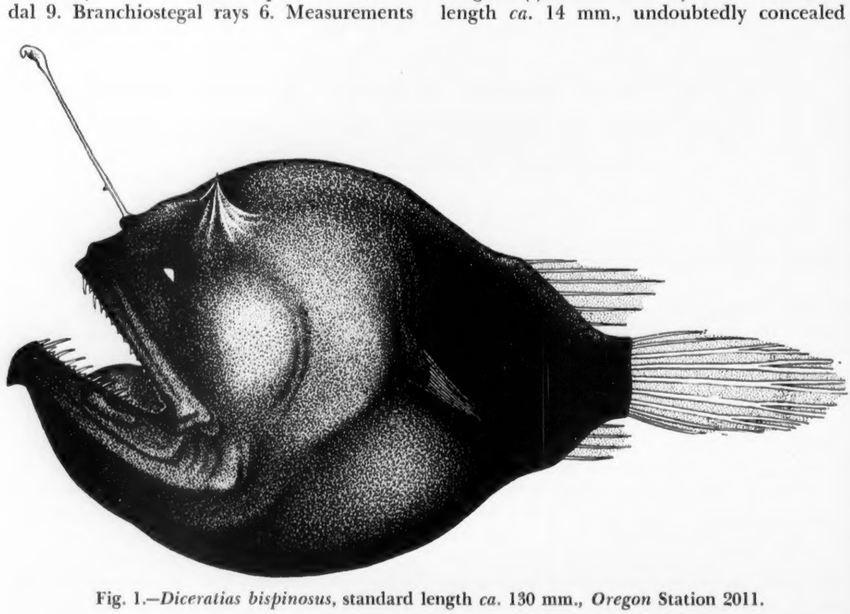

Fig. 1.—*Diceratias bispinosus,* standard length *ca.* 130 mm., *Oregon* Station 2011.

beneath skin in undamaged specimens. Symphyseal spine of lower jaw stout and blunt. Jaw teeth slender, depressible, longer in lower jaw than in upper, in two rows in lower jaw, possibly only one row in upper although there are subcutaneous (replacement?) teeth above. Longest mandibular tooth 6 mm., longest premaxillary tooth 4.5 mm. Vomer broad, with about 10 teeth, most of them rather large. Upper pharyngeal teeth well developed, in two groups, four teeth in each upper group, five in each lower group.

Illicium *ca.* 31.9 percent of standard length. Basal bone very short. A small papilla on illicium stem, about 8 mm. above its juncture with basal bone. Esca bulbous, with a blunt, curved terminal appendage, a small tentacle on the side, and a large black inner body. Second cephalic ray represented by a protruding pore, 1–1.5 mm. in diameter, situated about 6.5 mm. behind posterior end of protruding portion of basal bone; hard, rounded base of pore can be seen (dark-colored) and felt beneath the skin, which is torn in this region.

Color of head, body and pectorals entirely black where skin remains; dorsal and anal rays black basally, colorless distally; caudal rays colorless.

D. bispinosus has not been reported from the Atlantic until now, having been known previously from two adults and two larvae found in the Banda and Celebes seas in the Pacific, and in the Laccadive Sea in the Indian Ocean. A damaged ceratioid, reported as a new species, *Linophryne colletti* by Weber (1913) possibly belonged to this species. It was 90 mm. long and was found in the Bali Sea at a depth of 1,018 meters, under circumstances that leave no doubt that it was caught on the sea floor and not in midwater. The three known adult specimens of *D. bispinosus* were also caught in bottom-fishing appliances.

Paroneirodes wedli (Pietschmann)

One specimen, total length *ca.* 50 mm., standard length 38.5 mm. *Oregon* Station 1911, 12° 44′ N., 82° 14′ W., western Caribbean Sea, 11 September 1957, 350 fathoms (640 meters).

Fin rays: dorsal 6, anal 4, pectoral *ca.* 11, caudal 9. Measurements in millimeters: depth *ca.* 28; peduncle depth 6; greatest width of head *ca.* 16; width at pectoral base *ca.* 7.5; length of head *ca.* 29; distance between tip of sphenotic spine and symphysis of upper jaw *ca.* 14; upper jaw 16.5; lower jaw 17; width of vomer *ca.* 7.5; illicium (including esca) 50; esca *ca.* 3.5; distance between last dorsal ray and base of middle caudal rays 4, between last anal ray and base of middle caudal rays 5; longest dorsal ray *ca.* 7.5–8; longest anal ray *ca.* 7; longest caudal ray 14.

Head and body, including illicium and esca, covered with extremely minute spines. Tail short, very compressed, rest of body and head much less so. Peduncle of pectoral fin very short. Caudal fin entirely free of skin. Lateral-line system visible on head but not on body, represented by minute papillae, darker in color than skin of head.

Sphenotic spines large. Eye moderate, subcutaneous but covered by transparent skin, its diameter *ca.* 2.5–3 mm., its distance from maxillary *ca.* 4.5 mm. Nasal tubes large, 3.5 mm. in front of eye. Cleft of mouth wide, reaching beyond eye. On outer surface of lower jaw on each side, *ca.* 6 mm. behind symphysis, a stout tentacle (gland?), attached only at its base, its length 5 mm.; apparent only after removal of skin from one side of lower jaw. Symphyseal spine of lower jaw stout and blunt. Teeth in jaws slender, slightly curved, in a single row in both jaws, usually one longer tooth and one shorter one alternating; lower jaw teeth longer than those of upper jaw. Longest mandibular teeth *ca.* 3.5 mm., longest premaxillary teeth *ca.* 2 mm. Vomer broad, with four teeth in a row at either end, none in center. Upper pharyngeal teeth in two groups, three or four teeth in each upper group, about eight teeth in each lower group.

Length of illicium about equal to total length of specimen. Basal bone very short. Illicium stem possibly with a few minute papillae, but these may only be pieces of torn skin. Esca club-shaped, rounded and transparent or whitish at distal end; a large black inner body present; and arising from base of transparent area a short, finger-like, whitish process, from the end of which protrude two groups of a few short, black, bristle-like filaments. Second cephalic ray *ca.* 2.5 mm. long, situated immediately behind the first, rather stout, ending in a rounded, club-shaped swelling.

Color black.

The type, and only specimen of *P. wedli* hitherto reported, was found at Madeira. *P. glomerosus* Alcock, which is perhaps the same species, is known from two small specimens, 26–28 mm., from the Bay of Bengal and the South Atlantic.

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CHICAGO NATURAL HISTORY MUSEUM, CHICAGO, ILLINOIS.

A Major Blood Group System in Atlantic Sea Herring

CARL J. SINDERMANN AND DONALD F. MAIRS

SINCE the first demonstration of individual differences in human erythrocyte antigens by Landsteiner (1901) and subsequent findings of racial differences in the frequencies of particular antigens (summarized by Mourant, 1954), intensive serological studies of a number of animal species have been made. Blood group systems have been developed for cattle (Ferguson, 1941; Owen, Stormont, and Irwin, 1947; and Stormont, Owen, and Irwin, 1951), chickens (Briles, McGibbon, and Irwin, 1950; Scheinberg, 1956), and several other avian and mammalian species. Such blood groups have been found to be genetically determined, and genetic explanations for their existence and relationships have been proposed. Recent attention has been directed toward identification of infraspecific groups of marine fishes by serological methods (Cushing, 1952, 1956; Ridgway, 1957; Ridgway, Cushing, and Durall, 1958; Sindermann, 1958; Suzuki, Shimizu, and Morio, 1958). This work has demonstrated the existence of individual variations in erythrocyte antigens of certain fishes and in some cases quantitative differences in the frequency of occurrence of antigens. These differences may prove as useful to fisheries investigations as human blood groups have to anthropological studies, or as cattle blood groups have to problems of lineage. If genetic distinctions exist among populations or races of marine fishes, as they have been found to exist in other animal species, certain of them may be disclosed by serological methods, and may be of value in population and migration studies.

With this point of view in mind, a study has been made of erythrocyte antigens of Atlantic sea herring (*Clupea harengus*), to determine if individual variations exist, and, if so, whether fish from different areas might be distinguished by different frequencies of particular antigens. Stocks of immature Gulf of Maine herring have been of principal concern, largely because of their economic importance and availability in quantity. The study reported here has been designed to discover whether or not they constitute one homogeneous group, or whether they may represent several more or less discrete groups.

MATERIALS AND METHODS

Blood samples were taken from immature herring of age groups 1 and 2 in summer and autumn of 1957 and 1958. More than 800 individual fish were bled, from catches which ranged geographically from Kennebunkport, Maine, to Saint Andrews, New Brunswick. Blood was obtained by cardiac puncture using a glass needle technique developed in this laboratory (Perkins, 1957) and was either citrated or allowed to clot. Cells from citrate tubes or clots were washed 3 times in 1.5 percent saline and used in approximately 4 percent suspensions in saline. Preliminary work involved testing herring cells with a variety of normal sera (cod, haddock, lamprey, sheep, horse, lobster, alewife, cattle, rabbit) to see if individual differences in reactions could be detected. Cell agglutination tests were also attempted with antisera prepared in rabbits and chickens by injections of pooled and individual samples of washed herring cells, as well as cod, lamprey, and alewife cells. Tests were run at room temperature within 72 hours from the time the blood was taken, although reactions of refrigerated cells did not change noticeably up to 10 days. Tube agglutination tests were made, using 0.2 ml. serum dilution and .05 ml. of 4 percent cell suspension. Readings were taken after 15 minutes incubation at room temperature and 30 seconds centrifugation.

Normal lobster (*Homarus americanus*) serum and rabbit anti-herring serum provided most definitive separation of individual her-

ring samples, and these reagents were used in later quantitative studies. For this quantitative work a pool of serum from 12 lobsters (labelled BHL2) was used throughout. This pool was frozen in small aliquots and was thawed just prior to use. A rabbit antiserum, prepared by injecting pooled washed cells of 50 Nova Scotia herring, and labelled NSFH16R was also used throughout. As with the lobster serum, this antiserum was frozen in small aliquots which were thawed and heat-inactivated to destroy complement activity just prior to use.

Demonstration of Erythrocyte Antigen C

Marked individual differences in reactions of herring cells were detected with lobster serum and rabbit anti-herring serum. Erythrocytes of most fish were strongly agglutinated by lobster serum (BHL2) to dilutions of 1:128, and by rabbit anti-herring serum (NSFH16R) to dilutions of 1:1024. Cells of certain herring, however, were not agglutinated by lobster serum beyond the 1:4 dilution, or by the rabbit antiserum beyond the 1:32 dilution. Differences of this magnitude suggested real variation in the antigenic content of herring erythrocytes. Table 1 illustrates the types of reactions found. The degree of agglutination was recorded conventionally in descending order from 4,

Table 1

Reactions of Rabbit Anti-herring Serum (NSFH16R) and Lobster Serum (BHL2) with Erythrocytes of Ten Individual Herring from the Isles of Shoals, Maine

Rabbit anti-herring serum (NSFH16R) dilutions	Erythrocytes of individual herring									
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
1:64	4	0	4	4	0	4	4	4	4	3
1:128	3	0	4	4	0	3	4	4	3	2
1:256	3	0	4	3	0	2	4	3	2	2
1:512	2	0	3	2	0	1	2	2	1	1
1:1024	2	0	1	2	0	0	1	1	1	1
Lobster serum (BHL2) dilutions										
1:8	4	0	4	4	0	4	4	4	4	3
1:16	4	0	3	4	0	3	4	3	3	3
1:32	3	0	3	4	0	3	3	3	3	2
1:64	2	0	2	3	0	2	2	2	1	1
1:128	2	0	1	2	0	0	1	0	1	1

Table 2

Results of Absorbing Rabbit Anti-herring Serum (NSFH16R) with Erythrocytes of Five Individual Herring from the Isles of Shoals, Maine

Antiserum NSFH16R absorbed with erythrocytes of individual herring	Erythrocytes of individual herring									
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
#1	0	0	0	0	0	0	0	0	0	0
#2	2	0	2	2	0	1	1	2	1	1
#3	0	0	0	0	0	0	0	0	0	0
#4	0	0	0	0	0	0	0	0	0	0
#5	2	0	3	1	0	1	1	2	1	1

representing complete agglutination, to 0, indicating no agglutination.

Cells from fish numbered 2 and 5 were negative with both rabbit anti-herring serum (NSFH16R) and lobster serum (BHL2) at the dilutions used, whereas cells of other fish were clearly positive at the same dilutions. These reactions suggested the existence of at least two antigenic types—those which reacted strongly with certain antibodies in the sera used, and those which reacted weakly or not at all with such antibodies. Absorptions of the antiserum supported this hypothesis, as illustrated in Table 2. The absorptions of specific antibodies were made by incubating one part herring cells and five parts diluted antiserum at room temperature, usually for fifteen minutes. After this incubation period, the absorbing cells were centrifuged and the supernatant tested against an aliquot of the cells used for absorption. One absorption was usually sufficient to remove all antibodies reactive with antigens on the absorbing cells.

Absorption by cells of fish number 1, 3, and 4, which in Table 1 were found to be strongly reactive, removed antibodies for the absorbing cells and all others. Absorption with weakly reactive or negative cells of fish number 2 and 5 removed antibodies for the absorbing cells and other weakly reactive ones at the dilutions used in absorptions (1:10), but left antibodies which agglutinated strongly reactive cells. For ease of description, and as a first approximation of reality, the erythrocyte antigen resulting in strong reactions with unabsorbed antiserum and in agglutinations with absorbed antiserum has been labelled antigen "C." Cells

from individual fish could then be designated as "C-positive" or "C-negative." A quantity of rabbit anti-herring serum (NSFH-16R) was absorbed with C-negative cells, tested and frozen in small aliquots, and thereafter constituted a reagent for detection of the presence or absence of antigen C, since only C-positive cells would be agglutinated by it.

Geographic Variation in the Frequency of Occurrence of Antigen C

After demonstration of individual variations in herring erythrocyte antigens and development of reagents capable of clearly distinguishing C-positive from C-negative fish, quantitative studies were made of the frequency of occurrence of each type in immature herring stocks. Cells were tested with lobster serum (BHL2), unabsorbed rabbit anti-herring serum (NSFH16R), and the reagent prepared by absorbing NSFH16R with C-negative cells. The geographic distribution of samples and results of tests for the presence or absence of Antigen C are summarized in Table 3 and presented graphically in Figure 1.

With Mount Desert Island as a boundary, Antigen C occurred in 97.7 percent of "eastern" immature herring, while it occurred in only 77.0 percent of "western" herring of comparable age. Chi-square analysis ($X^2 = 9.73$, $p = .0018$) furnished evidence for a significant difference in the frequency of occurrence of the antigen in the two areas, and suggested that "eastern" and "western" stocks may originate, at least in part, from different spawning populations. The data point to the existence of two serologically distinguishable subgroups of immature Gulf of Maine herring, with a rather clear transition in the vicinity of Mount Desert Island.

Table 3

Distribution of Antigen C in Immature Gulf of Maine Herring

Area of sampling	Numbers of samples	Numbers of fish tested	Numbers of fish C-positive	Percent of fish C-positive
"Eastern" herring				
Point Lepreau, N. B. to West Quoddy Head	6	213	208	97.6
West Quoddy Head to Mount Desert Island	3	88	86	97.7
Total	9	301	294	97.7
"Western" herring				
Mount Desert Island to Pemaquid Point	3	139	111	79.8
Pemaquid Point to Cape Small	4	183	132	72.1
Cape Small to Cape Porpoise	5	192	153	79.6
Total	12	514	396	77.0

Discussion

It is difficult to obtain direct genetic information about pelagic marine fishes. Erection of blood group systems in marine teleosts, and especially the development of genetic theories to explain them, must at present draw heavily upon investigations of other animal species. This work in man, chickens, cattle, and goldfish has clearly indicated genetic determination of erythrocyte antigens. Preliminary work on other Atlantic clupeoid fishes has suggested the existence of an antigen system similar to that here described for herring. Since certain of the clupeoids—the alewife (*Pomolobus pseudoharengus*) in particular—are anadromous, with short spawning runs to restricted bodies of water, they may constitute more suitable material for direct genetic studies than marine species. However, until such evidence accumulates, differences in fish erythrocyte antigens of the nature reported in this paper for herring Antigen C, should prove to be instructive and useful as tools in population studies.

With human, cattle, and chicken erythrocyte antigen research, increasing complexity of blood groups emerged with continued investigation. This may prove to be true with fishes too, so that the system here described for herring may eventually require elaboration. That several serological subgroups or even dosage effects may possibly be included in "Antigen C" is suggested by individual differences in agglutination titer. This however, should not modify the basic findings reported in this paper.

Until more precise reagents become available, tests for the presence or absence of Antigen C have utility in their present form. They have demonstrated significant differences in the frequency of occurrence of this antigen in immature Gulf of Maine herring, and have pointed to the existence of two serologically recognizable subgroups—eastern and western. It seems pertinent here that a recently completed three-year study of parasite distribution and abundance in such fish (Sindermann, 1957*a*, 1957*b*) has pointed to

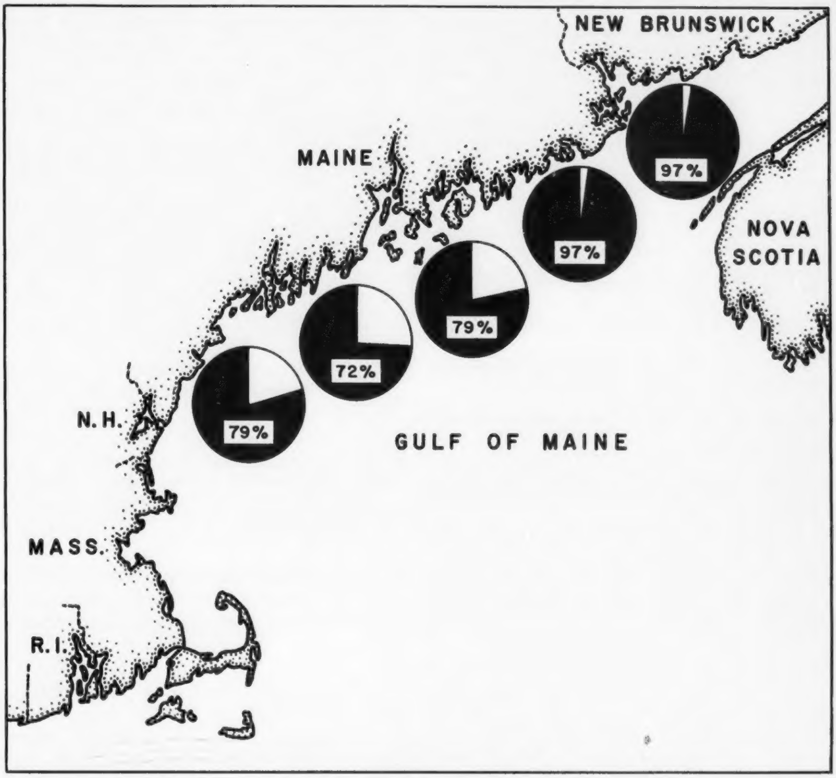

Fig. 1.—Frequency of occurrence of erythrocyte Antigen C in immature Gulf of Maine herring.

the same conclusion—the existence of two subgroups of immature herring in inshore waters of the Gulf of Maine, with an area of mixing in the vicinity of Penobscot Bay and Mount Desert Island.

Future direction for serological studies of herring seems clear. Further refinement of the C system should be made; search should be continued for other blood group systems in the species; and genetic studies should be attempted, with this or a closely related anadromous species. It is also obvious that similar studies must be made of actual spawning aggregations, even though this may be more difficult because of the lack of an extensive fishery for mature herring in the Gulf of Maine. With sufficient exploration and standardization of methods, serological techniques—particularly those concerned with blood group antigens—should take their place beside the more traditional ways of studying populations and migrations of herring or any other species of fish.

Conclusions and Summary

A major blood group system in immature Atlantic sea herring has been distinguished with normal lobster serum and rabbit anti-herring serum. The erythrocyte antigen detected by such sera has been tentatively called antigen "C." Cell agglutination tests and antiserum absorptions have suggested a simple situation of presence or absence of the antigen in individual fish, so that they may be classified as C-positive or C-negative, although the possibility of subgroups in the C-positive fish remains. Population heterogeneity in immature Gulf of Maine herring has been indicated by significant differences in the frequency of occurrence of Antigen C. "Eastern" herring have an antigen frequency of 97.7 percent, while "western" herring have

a frequency of only 77.0 percent. This evidence points to the existence of at least two subgroups of immature fish, probably drawn from different spawning populations, with a transition in the vicinity of Mount Desert Island—a finding which agrees remarkably well with data from parasitological studies.

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A Synopsis of the Postlarvae of Western Atlantic Lizard-fishes (Synodontidae)

Robert H. Gibbs, Jr.

Introduction

THE last major systematic treatment of the lizard-fish family Synodontidae was that of Norman (1935), in which ten species of the three genera considered were listed as occurring in the Western Atlantic. Since that time, three new species have been described from this region. The following are the currently recognized (or at least not yet invalidated) western Atlantic species.

Trachinocephalus myops (Schneider)
Synodus bondi Fowler
Synodus cinereus Hildebrand
Synodus foetens (Linnaeus)
Synodus intermedius (Spix)
Synodus meleagrides (Valenciennes)
Synodus poeyi Jordon
Synodus saurus (Linnaeus)
Synodus synodus (Linnaeus)
Saurida brasiliensis Norman
Saurida caribbea Breder
Saurida normani Longley
Saurida suspicio Breder

Most of the published accounts of the lizard-fishes deal with the metamorphosed forms; extremely few have mentioned the postlarvae. Norman (1935) reviewed the knowledge of postlarval forms up to that time, noting that four (possibly five) species of *Synodus*, one of *Saurida*, and *Trachinocephalus myops* had been described. Of these, *Synodus saurus, Synodus synodus, Synodus foetens,* and *Trachinocephalus myops* are western Atlantic species. Gopinath (1946) and Nair (1952) have added Indian species, and Breder (1944) has described the metamorphosis of *Synodus foetens* from Florida. In view of the paucity of information

on these postlarvae, the present work represents an attempt to form a suitable basis for their recognition.

Methods

Fin rays were counted as the total number of elements (thus not principal rays only) in each of the fins. This was usually most easily done under a binocular microscope with the specimen immersed in water. In those specimens where it could be verified, the number of lateral-line scales was equal to the number of myotomes in the same length; it was possible, therefore, to make this count even when all the scales were missing.

The species were identified principally by the meristic characters given by Norman (1935) and in the descriptions of the three subsequent species (Longley, 1935; Fowler, 1939; Hildebrand, 1948). On this basis, the distinctive pigment patterns could be superimposed. Using these criteria, I have been able to distinguish eight possible species in the available material.

Synodus bondi, cinereus, intermedius, and *meleagrides* and *Saurida caribbea* have not been identified. *Synodus meleagrides,* according to Norman (1935) may be synonymous with *S. synodus. Synodus intermedius* and *S. poeyi,* while apparently good species (cf. Longley and Hildebrand, 1941), are quite similar, the major differences being the relative lengths of the dorsal fin rays and the development of a mandibular knob. The specimens here treated as *S. poeyi* are so-called because the meristic characters fall more toward the trend of that species than of *S. intermedius* as given by Norman (1935), and because the anterior dorsal rays reach beyond some of the succeeding ones. Since the ranges of variation of the meristic characters of the two species overlap, and since postlarval fin shapes may not be similar to the adult form, the present specimens may quite possibly represent *S. intermedius* or be a composite, rather than *S. poeyi* alone.

Materials

The majority of collections studied were taken by the M/V *Oregon* of the U. S. Fish and Wildlife Service in the western Gulf of Mexico. These were examined through the courtesy of Royal D. Suttkus of Tulane University (TU) and Loren P. Woods of the Chicago Natural History Museum (CNHM). Specimens from Florida and the Bahamas were borrowed from the Bingham Oceanographic Collection (BOC) through James E. Morrow. A few Caribbean collections were made by the R/V *Crawford* of the Woods Hole Oceanographic Institution and by Frank J. Mather of the same institution. The small remainder was collected by me, for which opportunities I am deeply indebted to James L. Squire and Harvey R. Bullis, Jr., both of the Fish and Wildlife Service. Most of these last collections have been deposited in the Museum of Comparative Zoology (MCZ).

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Synodus saurus.—BOC. Pawnee Sta. 6. Gun Cay, Bahamas. February 27, 1927.

Saurida brasiliensis.—CNHM 64142. Gulf of Mexico. Alacran Reef, Campeche Banks. August 27, 1951. TU 11920. La., Gulf of Mexico near mouth of Mississippi R. June 30, 1954. BOC 3643. Gulf of Mexico. 27° 34′N, 95° 35′W. March 31, 1935. BOC. *Atlantis* Sta. 2853H. April 10, 1937. BOC. *Atlantis* Sta. 2853G. April 10, 1937. MCZ 40017. Gulf of Mexico. *Oregon* Sta. 1600. November 23, 1956. MCZ 40012. Gulf of Mexico. *Oregon* Sta. 1607. Arcas Cay. November 26, 1956.

Saurida normani.—CNHM 64143. Gulf of Mexico. Arcas Cay. December 6, 1952.

Saurida suspicio.—BOC 111. Misteriosa Bank. April 10, 1925 (Paratype). MCZ 40018. Near edge WNW of Buck Island, St. Croix, Virgin Islands. June 17, 1957.

Habitat and Metamorphosis

Nearly all the materials used were collected from shipboard by means of a dipnet at a night light. Most specimens were taken near land in the vicinity of, if not in, relatively shallow water. Some collections, however, were made at a considerable distance from any shallow water. This is notably true in the case of *Trachinocephalus myops*, which was taken on occasion in or near the Gulf Stream over more than 1,000 fathoms.

No single time of year appears to predominate in the occurrence of the examined postlarvae, specimens having been collected in every month of the year. *T. myops* has been taken unmetamorphosed in July, August, October, and November; *Synodus foetens* in February, May, June, July, August, November and December.

The precise time of metamorphosis is difficult to ascertain, as pigmentation is assumed, and slight changes in body form take place apparently fairly gradually. The following are the size ranges that I have examined which were considered unmetamorphosed. Obviously there is considerable variation in size at metamorphosis.

Table 1

Lateral-Line Scales or Myotomes

Meristic Characters of Lizard-Fishes, from Specimens Used in this Study

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
Trachinocephalus myops												3	5	4	3	4						
Synodus foetens														2	1	3	3	6	8	2	1	1
Synodus poeyi	2	3	5	4	10	13	10	8	1													
Synodus synodus														1	2	3						
Synodus saurus																6	1					
Saurida brasiliensis		1	6	3	5	5	1	1														
Saurida normani									1	1	2	1	1									
Saurida suspicio									2	1	1											

	Dorsal Rays					Anal Rays									Pectoral Rays					
	9	10	11	12	13	8	9	10	11	12	13	14	15	16	9	10	11	12	13	14
Trachinocephalus myops				7	10							4	12	1			1	8	7	
Synodus foetens	1	12	22	3				1	7	44	4							13	24	7
Synodus poeyi	1	25	26	3			4	51	6							2	22	18	2	
Synodus synodus			1	2	3	1	5										1	3	2	
Synodus saurus			1	6				5	2										7	
Saurida brasiliensis	2	10	11	3				4	15	6					1	2	2	11	2	
Saurida normani		4	1					1	2	3							2	2		
Saurida suspicio		1	3						1	3								3	1	

Trachinocephalus myops
28.0–43.0 mm.
Synodus foetens
15.8–41.0
(32.5–39.6 metamorphosing)
Synodus poeyi
16.0–29.0
(33.3 metamorphosing)
Synodus synodus
25.0–36.7
Synodus saurus
(46.4 metamorphosed)
Saurida brasiliensis
20.6–29.5
Saurida normani
18.8–26.7
Saurida suspicio
34.0–39.0

Synopsis of the Recognized Genera and Species

1*a*. Two rows of palatine teeth on each side. All pectoral rays of almost similar length. Pigment at base of anal fin consisting of

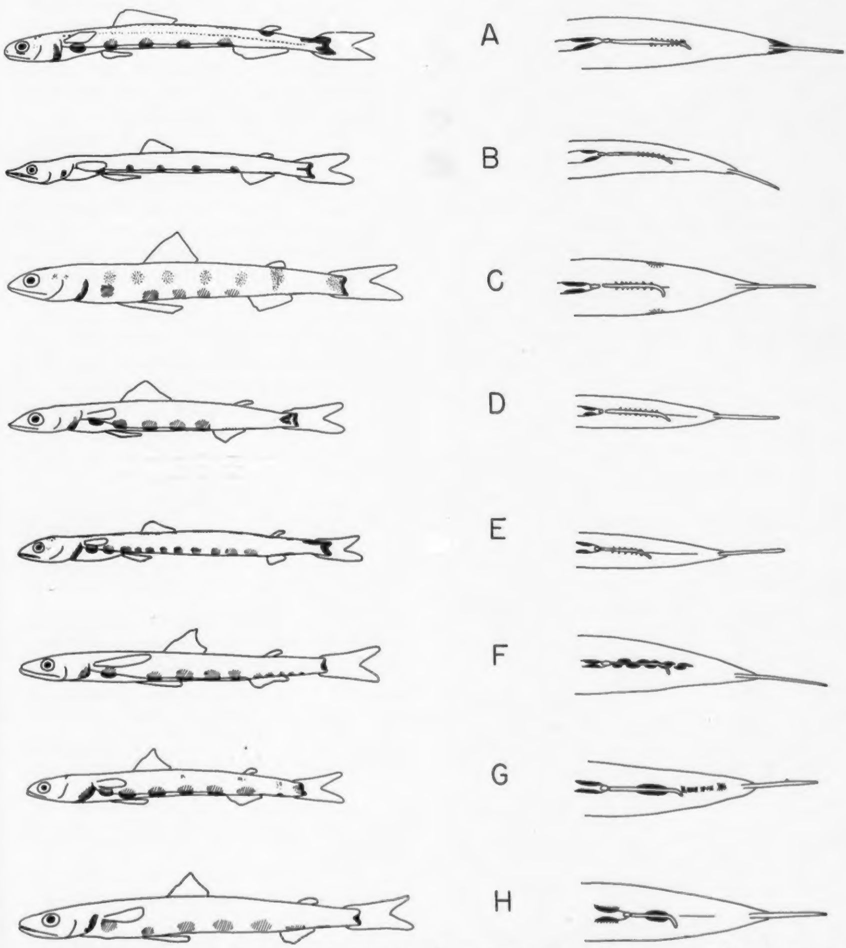

Fig. 1.—Left: lateral view of entire animal. Right: ventral view of posterior end of body. A. *Trachinocephalus myops*, 43 mm. B. *Synodus foetens*, 41 mm. C. *Synodus saurus*, 48 mm. D. *Synodus poeyi*, 29 mm. E. *Synodus synodus*, 32 mm. F. *Saurida brasiliensis*, 25 mm. G. *Saurida normani*, 27 mm. H. *Saurida suspicio*, 35 mm. All standard lengths.

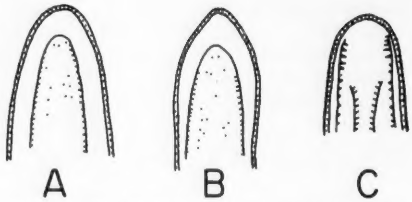

Fig. 2.—Roof of mouth showing palatine teeth. A. *Trachinocephalus myops*. B. *Synodus poeyi*. C. *Saurida brasiliensis*.

a pair of large, deep lying spots on each side of the mid-base or of a staggered series of several large spots. Scales tend to be adherent........genus *SAURIDA* 2

1*b*. A single row of palatine teeth on each side. Pectoral rays graduated, the mesial rays longest. Pigment at base of anal fin consisting of pairs of superficial small spots at the base of the last 5 to 8 rays. Scales tend to be deciduous............4

2*a*. Pigment at anal base consisting of a staggered series of several spots on each side. Lateral-line scales (myotomes) 44–50, usually 45–48.......*Saurida brasiliensis*

2*b*. Pigment at anal base consisting of a single pair of large spots. Lateral-line scales (myotomes) 51–55..............3

3*a*. Pigment on midventral line of caudal peduncle behind anal fin consisting of a series of discrete melanophores (with dispersed pigment in the sample examined). *Saurida normani*

3*b*. Pigment on midventral line of caudal peduncle behind anal fin consisting of a narrow back line......*Saurida suspicio*

4*a*. A row of discrete melanophores along lateral line. Melanophore concentrations forming a dark spot at base of adipose dorsal fin and a prominent dark patch at caudal base. Anal rays 14–16 *Trachinocephalus myops*

4*b*. No melanophores on lateral line. Usually no dark spot at base of adipose dorsal. Patch at caudal base often present, but seldom prominent. Anal rays 8–13..............genus SYNODUS 5

5*a*. Eleven or more large ventrolateral pigment spots in peritoneum between operculum and anal origin. Usually 9 anal rays..................*Synodus synodus*

5*b*. Six large ventrolateral pigment spots in peritoneum between operculum and anal origin. Usually 10 or more anal rays.............................6

6*a*. Body slender (see illustration). Snout decidedly acute. Ventrolateral peritoneal spots usually much smaller than interspaces. Pigment at caudal base forms a dark chevron pointing craniad with a short, narrow line extending forward from its apex. Anal rays usually 12 *Synodus foetens*

6*b*. Body less slender. Snout usually blunt. Ventrolateral spots usually equal in length or longer than interspaces. Pigment at caudal base variable, but without a narrow, anteriorly-directed midlateral line. Anal rays usually 10......7

7*a*. Ventral side of caudal peduncle with a narrow black line extending most of its length. Pigment at caudal base a bar preceded by a separated, less intense blotch. Pectoral rays usually 11–12. Lateral-line scales (myotomes) 43–51 *Synodus poeyi*

7*b*. Ventral side of caudal peduncle with a very short, narrow black line. Pigment at caudal base a bar preceded by a contiguous, less-intense blotch. Pectoral rays 13. Lateral-line scales (myotomes) 58–59.....................*Synodus saurus*

Acknowledgments

For valuable suggestions during the preparation of the manuscript, I want to thank W. W. Anderson, David K. Caldwell, and Jack W. Gehringer. Much of the work was done under NSF Grant 2102 at the Woods Hole Oceanographic Institution.

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A New Gobioid Fish of the Genus *Eviotops* from the Philippines

Robert R. Rofen

IN an attempt to fill gaps in my knowledge of gobioid fishes, I discovered an interesting new species of the monotypic genus *Eviotops* Smith in A. W. Herre's Philippine collections housed in the Natural History Museum, Stanford University.

Genus *Eviotops* Smith

Eviotops Smith 1957, p. 825 (original description; type species by original designation *Eviotops infulatus* Smith.—Smith 1958, p. 144 (diagnosis).

The species referred to the genus *Eviota* are very similar and often difficult to distinguish, but they do appear to fall into two natural groups, which are here recognized as genera: *Eviotops* Smith with two species, and *Eviota* Jenkins with the remaining large number of species. *Eviotops* was described by Smith on the basis of such characters as the elongate nasal tube, much reduced interorbitals, and blade-like elongated dorsal spines, all of which are shared with species of *Eviota*. However, *Eviotops* is distinct from all specimens of *Eviota* examined in having all the pectoral fin rays simple instead of branched, and this character together with the extreme length of the nostrils is believed to indicate full generic status. *Eviotops* was previously known only by the type species, *Eviotops infulatus* Smith, from the Seychelles.

Eviotops storthynx, *sp. nov.*

Holotype.—Male 17.3 mm. in standard length, from Bungau, Sulu Province, Philippine Islands; collected Sept. 17, 1940, by the Herre 1940–41 Oriental Expedition; Stanford University No. 52108.

Paratypes.—One male 14.8 mm. in standard length; same data as holotype; SU 39853. One female 12.6 mm. in standard length, from Coron, Busuanga, Philippine Islands; collected by the Herre 1940–41 Oriental Expedition, June 24, 1940; SU 38510.

Description.—All types in good condition but scales mostly absent in paratypes. The following description is based on all types and agrees with holotype, unless otherwise specified. The proportions are those of the two larger types, unless marked with an asterisk; in the latter case measurements are of all three types. The counts are of all three types (see Table 1).

Body short, moderately stocky, oval in cross-section, strongly compressed. Greatest body depth (under end of first dorsal fin) 3.5–4.5* in standard length. Caudal peduncle deep, strongly compressed, almost twice as long as deep; its length to end of dorsal fin base 4.1–4.3* in standard length, its least depth 2.2–2.2* in head length. Anus situated immediately before anal fin. Genital papilla of female short, flat, broader than that of male, posterior tip emarginate, not reaching to anal fin origin. Head moderately large, compressed, deeper than wide, its width slightly greater than body width; its length 3.1–3.5* in standard length. Profile rounded, snout outline straight between tip of snout and upper edge of eye; nape also straight; eye protrudes into upper profile of head. No transverse groove behind eyes. Nostrils prominent; the anterior nostrils form extraordinarily long, thin, round tubes, extending straight forward well before head. Each posterior nostril is an open pore at the anterior upper edge of eye, its lower border with a low rim. Snout short, its length 4.3–4.7 in head, less than eye diameter. Eye oval, large, situated high and anteriorly, directed laterally; its diameter 4.0–4.5 in head. Interorbital very narrow and flat, its least bony width 6.5–7.0 in eye diameter.

Mouth relatively small, moderately oblique, posterior edge of maxillary extending to a vertical under anterior third of eye. Teeth in jaws well developed, depressible, in two separate series; outer series a dispersed row of enlarged canines; inner series a band of villiform teeth. Approximately 5–8 enlarged teeth in outer row on each side in each jaw. Villiform band in each jaw broader at symphysis; teeth in approximately three irregular rows, the teeth very tiny in upper jaw, the innermost row largest in the lower jaw. No teeth on palate. Three complete gill arches present, slit behind last. Gillrakers short, blunt, compressed, lacking spines, length less than width of gill arch. Gillrakers on first arch 2 + 1 + 6 in largest paratype (counted from upper end). All gillrakers on first arch equal in size, the raker in angle not longer than others. Two pseudobranchiae on inside of operculum in largest

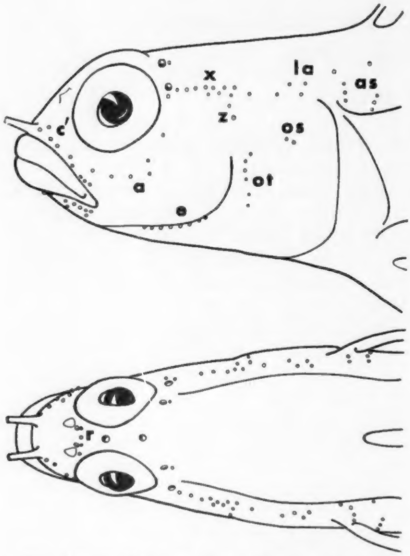

Fig. 1.—Outline of head of the holotype of *Eviotops storthynx*, new species, illustrating the open pores and genipores. The symbols indicate genipore series and are after Sanzo (1911).

paratype. Gill opening moderately restricted, open laterally somewhat below a level from lower edge of pectoral fin base. Gill membranes broadly joined to isthmus. Branchiostegal rays 5 + 5.

Sensory line system on head somewhat difficult to distinguish. The following description of the sensory line system on the head is based upon the terminology of Sanzo (1911). Head canals and pores not as large as in *Eviota*. The interorbital is very narrow and thus the supraorbital canal is single. Coronal pore present in holotype, anterior to a vertical from posterior edge of eye; minute in smaller paratype, absent in larger paratype. Anterior interorbital pore median, in middle of interorbital. Postorbital pores present in holotype. Anterior nasal pore and supratemporal canal absent. Posterior nasal pore present, opening straight forward. Anterior otic pores present, but posterior otic and intertemporal pores absent. All but third preopercular pore absent. Infraorbital canal and pores absent. Genipores small and inconspicuous. A few scattered *c* and *a* series of genipores under eye, *x* genipores behind anterior otic pore; *z* series present at preopercular margins; *la* and *as* pore series above and before pectoral fin; *i* and *e* series prominent and complete; short *os* and *ot* and *z* series present; one or two pair *r* papillae present; other genipore series absent.

Squamation well developed on body, including along dorsal fin base; nape and head naked. Most scales finely ctenoid on posterior margin, those on side of body wider than long, with approximately 20–30 ctenii; focus near central posterior edge; radii straight across scale; circuli approximately 25, less than half the number present in some species of *Eviota*, running off posterior edge of scale. Lateral scale series 22 in smallest paratype; some scales missing, but perhaps 27 in holo-

TABLE 1

MEASUREMENTS OF *EVIOTOPS STORTHYNX*, NEW SPECIES, IN PERCENT OF STANDARD LENGTH

Measurements	Holotype S.U. 52108	Paratype S.U. 39853
Standard length, in mm.	17.3	14.8
Body depth	28.9	25.7
Caudal peduncle least depth	15.0	14.2
Caudal peduncle length to dorsal base	23.1	24.3
Head length	32.4	31.8
Snout length	7.5	6.8
Eye diameter	8.1	8.8
Interorbital width	1.2	1.4
Predorsal distance	33.5	35.1
Longest ray first dorsal fin	40.4	39.2
Longest ray second dorsal fin	19.7	20.9
Preanal distance (to anal fin origin)	60.1	59.4
Longest anal fin ray	17.9	17.6
Pectoral fin length	33.5	31.1
Pelvic fin length	33.5	33.8
Caudal fin length	28.9	28.4

Fig. 2.—Pelvic fins of holotype of *Eviotops storthynx*, new species, showing the multiple branching of the rays.

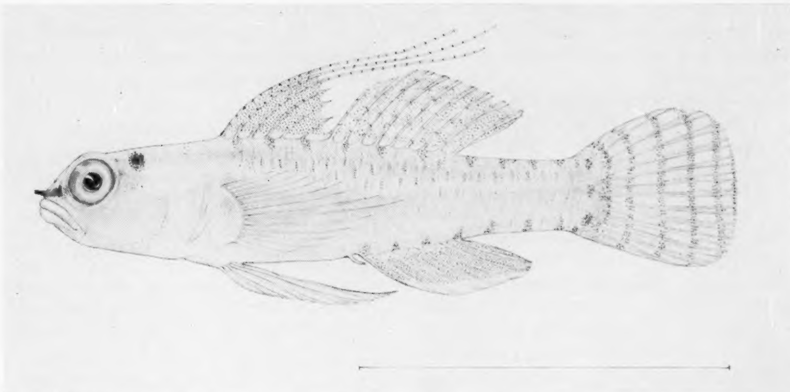

Fig. 3.—Male paratype of *Eviotops storthynx*, new species, S.U. 39853, from Busuanga, Philippine Islands.

type. Oblique scale series between anal and dorsal fins seven in holotype, six in smallest paratype. Number of scales around caudal peduncle 11 in holotype, 12 in smallest paratype. No predorsal scales. Breast naked.

Dorsal fins prominent. Predorsal distance 2.8–3.0 in standard length. First dorsal fin origin at or before a vertical from hind margin of gill opening; males with first three rays greatly prolonged, blade-like, with a membranous fold in front and behind; female with entire fin low, rounded in outline, not as high as second dorsal. Second dorsal with a straight outline. Second dorsal origin at a vertical from urogenital papilla. End of second dorsal base slightly posterior to a vertical from end of anal fin base. Dorsal fin rays VI-I, 8½ in males, VI-I, 9½ in female. Anal fin similar to second dorsal, its origin under second ray of second dorsal. Anal fin rays I, 7½ in males, I, 8½ in female. Pectoral fin large, rounded, tips of the rays reaching past middle of dorsal and anal fin bases, distal two-thirds free from membrane. Pectoral fin rays 15 or 16 in both males. Pelvic fins separate, straight, curved outward, the outer tips free, fringe-like, reaching far past anal fin origin. Pelvic fin rays I, 5, the spine and innermost ray slender, simple, short. Caudal fin slightly rounded, principal rays 7 + 6, 11 divided rays. Vertebrae 25 in holotype and largest paratype; 10 prehaemal vertebrae (determined from X-rays of types).

Coloration.—General color light brown in preservative; types appear to have been translucent in life. Body lightly pigmented with a short vertical streak on each scale; no large spots present on body, except for a series of round dark spots on mid-ventral line from middle of anal fin base to caudal fin, and to a lesser extent a series on the mid-dorsal line posteriorly. Belly, breast, and head very lightly pigmented, except for a dark round spot immediately behind each eye and for dusky black anterior nostrils. There is a faint indication on the nape of the holotype of three or four transverse bands. First dorsal evenly dusky at base; outer edge of fin in female hyaline; free rays of male banded. Entire second dorsal light dusky black. Anal fin light dusky black, except for hyaline outer margin. Pectoral and pelvic fins hyaline. Caudal fin with spots at base and six or seven vertical black lines; remainder of fin hyaline with a few scattered melanophores.

Relationships.—This species belongs to the genus *Eviotops* because of the fringed pelvic fins, unbranched pectoral fin rays, remarkably produced anterior nostrils, naked breast, and elongate blade-like first dorsal fin rays in the male. *Eviotops storthynx* is sharply differentiated from the only other known species of the genus, *Eviotops infulatus* Smith, in many aspects of coloration (i.e., no mark on shoulder of *storthynx* versus a prominent dark brown mark on the shoulder in *infulatus*; no marks on nape, cheek or chest versus dark marks present; elongate dorsal rays in males banded versus no markings; dark spot present laterally behind eye versus absent). These two species also differ from each other in origin of dorsal fin (at or before

a vertical from gill opening versus well behind), transverse fold behind eye (absent versus present), otic pores behind eye (one versus two present).

Name.—*storthynx* [Gr.] = tusk, in reference to elongate anterior nostrils, which look like tusks.

Acknowledgments.—I am greatly indebted to Dr. A. W. Herre, Prof. George S. Myers, and Miss Margaret H. Storey for permitting me to study the specimens herein described from the Natural History Museum Collection at Stanford University. Dr. Leonard P. Schultz and Dr. Ernest A. Lachner allowed me to examine the paratypes of *Eviotops infulatus* Smith deposited by Prof. J. L. B. Smith at the U. S. National Museum. Prof. Myers has read the paper and made suggestions.

This study was supported by the George Vanderbilt Foundation at Stanford University. The illustrations are by Mrs. Eva Soule, staff illustrator.

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George Vanderbilt Foundation at Stanford University, Stanford, California.

Spawning Behavior of the Bluebreast Darter, *Etheostoma camurum* (Cope)

Donald I. Mount

A SEARCH of the literature indicates that nothing has been published concerning the breeding behavior of *Etheostoma camurum* (Cope). The few remaining populations, and the fact that the habitat is limited to deeper and faster riffles of larger streams, no doubt have been primary causes for this lack of data on the spawning habits.

This investigation, begun in January 1956, consisted of laboratory and field investigations of the life history of this species. Most of the observations and collections have been made in the lower 15 miles of Big Darby Creek, which enters the Scioto River in Pickaway County, central Ohio, at a point 25 miles south of Columbus. Observations were made on one riffle in Deer Creek, a stream parallel to Big Darby, to the southwest, which empties into the Scioto River 12 miles below the mouth of Big Darby Creek.

Method and Equipment

A description of the tray used to keep darters in the laboratory follows. This type of tray may be useful to other investigators studying riffle-inhabiting species, especially in view of the low construction cost.

In the spring of 1956, darters were held in standard laboratory aquaria, but did not spawn, even though they remained in healthy condition for periods up to seven months. Females ripened and were stripped by the method described by Strawn and Hubbs (1957:114–116), but would not spawn, presumably because of lack of a current.

The darters were kept in a tray two feet by four feet and six inches deep, which was constructed using ¾-inch exterior grade plywood for the bottom and ¾-inch white pine boards for the sides. A divider was placed in the center of the tray, leaving a space of one foot between it and each end of the tray. (see Figure 1.) Four rectangular holes, two inches by four inches, were cut in the sides and covered with ¼-inch transparent plastic. The entire tray was coated with plastic resin, glass cloth was fitted over the interior, and several more coats of plastic resin were applied over the cloth. The result was a rigid plastic casing which was very strong, waterproof, and inert. These plastic materials were purchased from a local boat dealer who sells them for use on boats. The total cost of the tray in 1957 was about $8.00, excluding labor.

In order to produce a current, a paddle wheel was installed to move the water around

the tray. It was made of medium weight galvanized sheet metal coated with plastic resin, and consisted of a ten-inch metal disc with four blades, each two inches square, riveted to the disc. The paddle wheel was attached to one end of a bicycle axle and a ten-inch pulley was attached to the opposite end. The hub of the axle was fastened to the edge of the tray. The source of power was a 20-watt, Model A, Marco air pump motor. A belt made of inner-tube rubber was used to drive the paddle wheel, which revolved at approximately 32 rpm's, producing a current velocity of six inches per second.

Numerous eddies, which were desired in this study, were formed at various places in the box. However, they could be eliminated and the water velocity increased by rounding the corners of the tray. Uneaten food and other waste accumulated under eddies and were siphoned out with a rubber tube.

Four females and two males were kept in this tray and were fed chopped earthworms cut in such lengths that the segments would wriggle for several minutes. This diet was supplemented with *Daphnia* and nymphs of Mayflies and stoneflies.

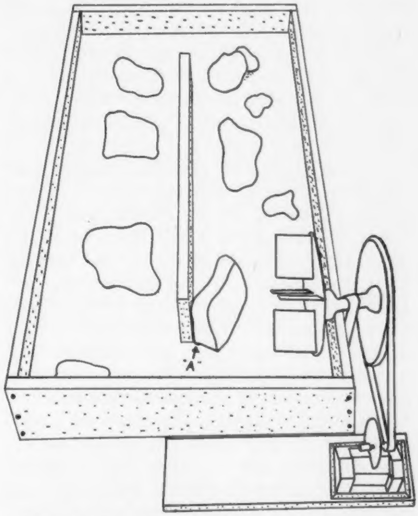

Fig. 1.—Tray in which darters spawned. A, shows spawning site.

Observations of Spawning

Laboratory observations.—The laboratory observations are based on darters kept in the laboratory in 1957 and 1958 in the tray described above. Since spawning behavior was not observed in the stream, the author does not know whether the behavior observed in the laboratory was typical.

There was a marked tendency for each of the two males to stay under a specific rock, and if one male approached another, a battle usually ensued. If these males had established territories, then the limits of the territories were not clearly defined, and occasionally they would move to another area for one or two days. These resting areas were defended against the intruding male, although fighting also occurred frequently in other areas. The fighting followed a pattern very much like the one described for *Etheostoma caeruleum* by Reeves (1907:45). There was frequent body contact and fin biting, but visible damage was never noted. In brief, the males began fighting by maneuvering over a small area, followed by several rapid lunges at each other, after which one male would be driven away, thus ending the fight. The brilliance of the coloration was heightened during the fighting, and two dark bands appeared immediately behind the pectoral fins, nearly encircling the body. For a description of coloration, see Trautman (1957:584). From March to July, the males frequently fought after feeding. Perhaps this was because the males saw each other when they swam out from beneath the rocks to feed. Fighting was most intense during the breeding season. Spawning was first observed on May 12, 1957, and on April 22, 1958.

While the males were fighting during the breeding season, the females would become pugnacious towards each other. They would dart at each other without body contact, and two black bands would appear behind the pectoral fins, just as on the males. The females held their fins rigid and erected the dorsal spines perpendicular to the body. Their breathing rate increased greatly. Fighting among the females was not observed until after they were gravid, which was two to three weeks after the males had begun to fight.

The females apparently stimulated the males to spawn and they also selected the spawning site. This site and the normal resting place of the male were never in close proximity. A female began her spawning ritual by swimming over the bottom in short darts. These darts appeared to be at random and were not always made in front of the male or near the spawning site. A male would follow and mimic her movements for as long

as one hour. During this period, frequent darts to the surface of the water were made, and the two often swam over the entire area of the tray many times. Usually, several times during this period, both would swim up from the bottom to the window as though attempting to get out.

The next phase of the ritual consisted of numerous "nosing" motions. These "nosing" motions consisted of the female raising her tail and putting her head down until she was nearly perpendicular to the bottom. Then she would swim forward so that her head was pushed through the gravel. "Nosing" motions were made seemingly at random over the entire tray, but wherever they occurred, they stimulated the male immediately and he would attempt to mount her.

It appeared that these motions were unsuccessful attempts of the female to bury herself in the gravel, and yet after five to fifteen minutes of such behavior, the female invariably would move directly to the spawning site ("A", Figure 1). In 1957, this site was under a swift eddy near the paddle wheel and the gravel was three inches deep at this point, whereas it was only one-half inch deep over the rest of the tray bottom. A "nosing" motion over the deeper gravel would result in the female burying herself until her back was even with the surface of the gravel, after which spawning occurred. Apparently, moving to the area of deeper gravel was a conditioned response.

In 1958, the depth of the gravel was increased to 1.5 inches over the entire tray, and a flat rock was placed on edge at the spawning site to increase the water velocity. The gravel around the rock was not over two inches deep and the water was turbulent but there was no well-developed eddy. However, the same fishes used the same spawning site again in 1958, even though conditions were different, as described above. In all cases, the eggs were deposited in the gravel around or under the rock. The reason that all spawning occurred at the same location may have been due to gravel depth, or to the fact that the current was swifter there.

When the female was buried in the gravel, the male would mount her and both would vibrate violently. The vibrations were so fast that they could scarcely be seen, and so strong that the water surface (four inches above the fish) would be agitated. The eggs were deposited during the vibrations, and usually the spawning pair would vibrate for a period of three to five seconds two or three different times before the female would emerge from the gravel. Three to five minutes elapsed between each period of vibration.

Spawning was always viewed from above, and so the exact position of the male could not be determined. Seemingly, the male partially wrapped his body around the female, similar to the position which Winn (1958: 195) described for *Etheostoma caeruleum*.

On at least one occasion, approximately 100 eggs were laid during a single period of vibration. On other occasions, eggs were known to have been deposited during several successive periods of vibration. The average number of eggs deposited by a female at one time was approximately one hundred. The exact number could not be counted because some were swept away by the current, and others may have been overlooked. Most of the eggs from a specific spawning were in an irregularly shaped cluster with sand particles incorporated into the mass. There were always some eggs which were adhering, singly, in pairs, and triplets, to other pebbles and sand particles, and were not attached to the egg mass. One would expect some eggs to be scattered, since they are deposited during the period of vibration. The number of times a female spawned in one season is not known definitely, but was at least three times. This figure was determined by dividing the number of recorded spawnings by the number of spawning females. The water temperature during the spawning period varied from 19° to 23° C. Spawning was not limited to any particular part of the day, but it occurred more frequently in the afternoon and evening. Several observations were made during the nights; but in all cases, no spawning was observed.

The incubation period at the prevailing temperature was seven to 10 days. About 50 percent of the eggs hatched, but all attempts to rear the young failed. Twice, the larvae reached the age of 10 days before death. Once the larvae were seen nipping at particles of suspended matter in the water, but did not seem to feed to any extent. The smallest young taken in the stream were 27 mm. standard length, and at this length the sexes were beginning to show different color patterns. Seines of $\frac{1}{16}$-inch mesh were used in an attempt to capture the young, but they were never taken before September. At that time, they were found at the foot of the riffle, where the water was deeper, the current slower, and the bottom composed of fine gravel. Adults at the same time were farther upstream in the riffle.

Field observations of spawning.—Field ob-

servations of spawning in 1956 and 1957 were greatly hampered by turbid, high waters. It requires five to 10 days for Big Darby Creek to return to normal level after a flood crest of 18 inches. A rise of 12 inches in water level is sufficient to prohibit one from walking and seining in the portion of the riffles in which the bluebreast is found. Silt from surrounding cornfields makes the water turbid after even a very light rain.

The males begin to show markedly increased coloration the last week in April, when water temperatures during the day are 13° to 15° C. By the middle of May, the females are ripe; the males are brilliantly colored and their throats are bright blue to bluish-black. Water temperature in mid-May averages 18° to 20° C. The last two weeks in May and the first week in June are weeks of greatest spawning activity, when water temperature reaches 21° to 24° C. There is a rapid decline of spawning from June 15, to June 25, and it is all completed by the end of the month. Raney and Lachner (1939:160) found ripe female *E. camurum* in French Creek in Pennsylvania on June 7, 1938. The bluebreast in central Ohio breeds after most of the other common species of darters have spawned.

During the spawning period, the breeding males are found at the crest of the riffle around large boulders which have fine gravel on the downstream side. Perhaps this fine gravel is the spawning site, since the darters held in the laboratory buried their eggs in gravel on the bottom of the tray. During the spawning period, females frequently are found farther downstream in the riffle than are males. On four dates, the bluebreast was observed in the stream through a glass-bottomed box.

Only one male was observed in 1956. This observation was made in Deer Creek, a stream similar to, but smaller than, Big Darby, on May 26. The male darter was observed for five minutes. He rested on a gravel area nine inches square which was immediately downstream from a boulder three feet in diameter. This boulder was near the crest of the riffle. No breeding activity was observed, but two females, one ripe and one spent, were captured within four feet of the boulder. A careful examination of the gravel revealed no eggs. It was raining at this time and the next day the stream was in flood, preventing further observations.

No observations could be made in 1957, due to turbid waters, but in 1958, several males were observed in Big Darby in essentially the same type of habitat niche as described above. Three males, assumed to be on their territories, were observed on May 17, again on May 30, and on June 7. Observations up to two hours in length were made and numerous females were seen in the immediate area of these three males. Some females were gravid, but no eggs were found, nor was spawning observed. An intruding young male was quickly chased away by an adult male on one date. High water from the first week of June until September prohibited other observations.

Summary

In the stream, adult bluebreasts were found during the spawning season only on riffles containing large boulders (12 to 20 inches in diameter) with some fine gravel around or under them. This fact, when considered in light of the observations made in the laboratory, indicates that spawning in the stream takes place around or under large boulders located near the crests of riffles, and that the eggs are deposited in the fine gravel found near these boulders. Most of the spawning takes place from May 15th to June 10th in central Ohio, when water temperatures range between 21° and 24° C.

Acknowledgments

I wish to thank Drs. E. E. Good and Milton B. Trautman for guidance in conducting this study, and my wife for her assistance in proof-reading and typing this manuscript.

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Ichthyological Notes

NOTES ON THE DIET AND CORRELATING STRUCTURES OF SOME CENTRAL PACIFIC ECHENEID FISHES.—Although the results of a stomach analysis of echeneid fishes have existed in the literature for over 100 years they have been largely overlooked by ichthyologists. Thus Bennett's (*Narrative of a whaling voyage . . . 2:271,* 1840) finding of ". . . small marine insects, shrimps, and fragments of delicate shells" in the stomachs of *Remora remora* is not widely known, and the food of this and related species is instead generally described as scraps from the meals of its hosts (sharks, marlin, sea turtles, etc.).

While the relation between an echeneid and a larger animal has become almost a classic example of commensalism, it is not clear with whom the idea originated. It was frequently mentioned at the turn of the century (Holder, *Sci. Amer. 82(21):331,* 1900; *ibid. 93(9):163,* 1905; Geare, *ibid. 87(5):73,* 1902) and has persisted until the present (Irvine, *The fishes and fisheries of the Gold Coast, pp. 211–2,* 1947; Norman, *A history of fishes, pp. 70,245–46,* 1949; Norman and Fraser *Field book of giant fishes, p. 176,* 1949; Smith, *The sea fishes of southern Africa, p. 340,* 1950; Bigelow and Schroeder, *USFW Serv. Fish. Bull. 53(74):484, 487,* 1953). Some of the above authors as well as Jordon (*Fishes, p. 679,* 1907) and Boulenger (*Teleostei, Cambr. Nat. Hist. 7:691,* 1922) state that echeneids are also carnivorous upon small fish such as sardines and herring; in this case the hosts merely serve for transportation to the feeding grounds at which the echeneids detach and actively pursue their prey. Smith (*op. cit.*) cites an earlier worker's observation (?) of echeneids consuming the hosts' faeces as a major dietary item.

Two recent papers suggest that the principal fare of echeneids may be entirely different from the foods suggested above. Szidat and Nani (*Rev. Inst. Invest. Mus. argent. Cienc. nat. 2(6):413,* 1951) observed the ectoparasitic caligid copepods *Achteninus* and *Pandarus* in the stomach of *R. remora,* and Maul (*Bol. Mus. Funchal 9:14,* 1956) found both caligid copepods and oxycephalid amphipods in this species. In addition, Maul discovered the planktonic heteropod *Atlanta* in the digestive tract of *Remoropsis brachypterus.* These authors postulate that echeneids and their hosts are symbionts, with the echeneid's function being parasite removal and consumption. Similar arrangements exist in birds which clean the hides and mouths of large reptiles and pachyderms, and also between wrasses of the genus *Labroides* and many other fishes (Randall, *Pacific Sci. 12(4):327–347,* 1958). Neither Szidat and Nani nor Maul had adequate specimens to depict the extent of parasite-feeding in the Echeneidae, and the present paper was prepared to illustrate the dietary trends apparent in several genera and species. The specimens studied are presently in the collections of the U. S. Fish and Wildlife Service, Honolulu.

Material examined.—Identification of echeneids was made with the aid of the keys of Maul (1956) and Schultz (*U. S. Nat. Mus. Bull. 180:256,* 1943), with the following species being present: *Rhombochirus osteochir* (Cuvier), *Remora remora* (Linnaeus), *Phtheirichthys lineatus* (Menzies), *Remoropsis pallidus* (Schlegel), and *Remoropsis brachypterus* (Lowe). In addition to meristic and morphometric characters, identification was also based upon the stained lateral-line scales, as illustrated by Maul. Some difficulty was experienced in distinguishing the species of *Remoropsis,* for in addition to specimens with the respective color patterns and scales of *pallidus* and *brachypterus,* there were others with *pallidus* coloration but *brachypterus* squamation. Scales were considered the more reliable criterion in such cases, and these specimens were labeled *brachypterus.* Szidat and Nani (1951) were followed in synonymizing *Phtheirichthys multiradiatus* Schultz with *P. lineatus* (Menzies). A summary of the data accompanying the specimens is presented in Table 1.

Viscera.—The digestive tracts were removed while the fish were soaking in water preparatory to transfer from formalin to alcohol. In no case were there evident any signs of improper preservation.

Two types of internal anatomy were encountered among the five species examined. In the first, typified by *Rhombochirus, Remora,* and *Phtheirichthys,* the digestive tract consisted of a short esophagus, a muscular J- or Y-shaped stomach, 4–7 large pyloric caeca, and a long, coiled intestine divided into anterior and posterior portions by a valvular fold. Both regions of the intestine were densely papillate internally in all species, but the intestinal length varied from 130 percent of the standard length in *Rhombochirus* to 40–60 percent of the standard length in *Remora* and *Phtheirichthys.* The smallest specimens of the latter genera had poorly differentiated viscera, the tract often appearing as a simple straight tube, which was internally papillate, from mouth to anus. No dietary dif-

TABLE 1

ECHENEID FISHES EXAMINED FOR FOOD

Species	Date	Latitude	Longitude	Sex	Standard length (mm.)	Host
Rhombochirus osteochir	7/20/50	05°42′N	171°54′W	F	161	*Makaira audax*
	?	North	Pacific Ocean	F	218	?
	8/30/56	09°32′S	136°55′W	M	240	*Makaira ampla*
	8/30/56	09°32′S	136°55′W	F	282	*Makaira ampla*
Remora remora	8/30/56	09°32′S	136°55 W	?	52	Attached to longline buoy
	2/10/56	21°23′N	158°29′W	M	84	*Pterolamiops longimanus*
	2/10/56	21°23′N	158°29′W	?	108	*Pterolamiops longimanus*
	8/21/52	07°02′N	140°46′W	M	131	*Pterolamiops longimanus*
	9/3/56	10°25′S	139°40′W	F	134	*Pterolamiops longimanus*
	3/18/56	00°11′N	139°53′W	M	154	*Pterolamiops longimanus*
	8/7/57	36°45′N	124°34′W	F	235	*Prionace glauca*
Phtheirichthys lineatus	8/27/56	12°16′S	133°20′W	?	44	Attached to longline bait (herring)
	8/28/56	11°23′S	134°32′W	?	46	In stomach of *Neothunnus macropterus*
	8/26/56	13°26′S	132°16′W	?	54	Attached to longline buoy
	9/29/51	21°24′N	158°15′W	F	300	Dipnetted beneath night-light
Remoropsis pallidus	9/1/56	07°30′S	138°57′W	F	119	*Makaira audax*
	8/21/52	07°02′N	140°46′W	F	126	*Makaira ampla*
	8/28/52	01°00′N	140°22′W	M	130	*Istiompax marlina*
	8/19/56	02°42′S	131°42′W	M	139	*M. ampla* or *I. marlina*
	9/1/56	07°30′S	138°57′W	M	148	*Makaira audax*
	8/19/56	02°42′S	131°42′W	M	167	*M. ampla* or *I. marlina*
	4/4/55	01°49′N	157°38′W	F	179	*Istiompax marlina*
	4/4/55	01°49′N	157°38′W	F	184	*Istiompax marlina*
	9/1/56	07°30′S	138°57′W	F	186	*Makaira audax*
Remoropsis brachypterus	8/19/56	02°42′S	131°42′W	?	53	*M. ampla* or *I. marlina*
	9/1/56	07°30′S	138°57′W	F	81	*Makaira audax*
	8/19/56	02°42′S	131°42′W	F	107	*M. ampla* or *I. marlina*
	8/19/56	02°42′S	131°42′W	F	110	*M. ampla* or *I. marlina*
	8/30/56	09°32′S	136°55′W	F	119	*Makaira audax*
	4/15/54	01°58′N	155°16′W	M	136	*Istiompax marlina*
	8/19/56	02°42′S	131°42′W	F	167	*M. ampla* or *I. marlina*
	8/18/56	00°57′S	132°24′W	F	197	*Istiompax marlina*

ferences were noted between small and large *Remora* or *Phtheirichthys*.

The second type of visceral anatomy occurred in *Remoropsis*, and resembled the juvenile condition of the other genera. The stomach and pyloric caeca were ill-defined or lacking so that the digestive tract was a straight papillate tube as shown by Suyehiro (*Jap. Jour. Zool. 10(1):217*, 1942). In this connection, we were unable to find the liver-like caecal mass noted by Suyehiro. Pyloric caeca were either absent or, in the largest specimens, occurred as a series of short evaginations arranged radially posterior to a diminutive stomach. Again no differences in food habits were detectable between specimens with and without caeca and stomachs.

Results of the food study.—Table 2 summarizes the occurrence of food material in the digestive tracts of each species. At this time I should like to acknowledge my indebtedness to Mr. Everet C. Jones, U. S. Fish and Wildlife Service, Honolulu, for identifying most of the invertebrate food organisms. The foods were grouped by categories suggestive of the following feeding methods: plankton feeding, preying upon ectoparasites and other attached organisms, and consumption of scraps. This classification is arbitrary in that it was not known whether certain crustaceans were attached or free-swimming, and also in that the source of the scraps could not be determined. Conceivably, scraps could represent remnants of the host's meal, portions of large prey captured by the echeneid itself, fragments of bait used to capture the host, table scraps from the fishing vessel, or undigested material from the host's faeces. Despite these vagaries the data fall into several patterns as discussed below.

All species except *R. brachypterus* consumed some food in the scrap category. In most cases individuals doing this were outnumbered by those taking other food, and scrap consumption

TABLE 2

ITEMS FOUND IN THE DIGESTIVE TRACTS OF ECHENEID FISHES. FIGURES REPRESENT NUMBER OF FISH CONSUMING THE ITEM

Food item	*R. osteochir*	*R. remora*	*P. lineatus*	*R. pallidus*	*R. brachypterus*
Planktonic organisms					
Amphipoda, hyperiids	—	3	1	1	2
Amphipoda, unidentified	—	—	1	—	1
Decapoda, *Lucifer* sp.	—	1	—	—	—
Decapoda, crab zoea	—	1	1	—	—
Decapoda, unidentified larvae	—	2	—	—	1
Copepoda (calanoid), *Candacia pachydactyla*	—	1	—	—	—
Copepoda (calanoid), *Candacia aethiopica*	—	1	1	—	—
Copepoda (calanoid), *Candacia* sp.	—	—	1	—	—
Copepoda (calanoid), *Scolecithrix* sp.	—	1	—	—	—
Copepoda (calanoid), unidentified	—	1	2	—	—
Copepoda (harpacticoid), *Sapphirina* sp.	—	1	—	—	—
Copepoda (harpacticoid), *Oncaea* sp.	—	—	1	—	—
Stomatopoda, larvae	—	1	1	—	—
Euphausiacea	—	2	1	—	—
Mysidacea	—	1	—	—	—
Ostracoda	—	—	1	—	—
Crustacea, unidentified fragments	—	1	—	—	—
Mollusca (heteropod), *Atlanta* sp.	—	—	—	—	1
Mollusca (pteropod), *Cavolinia tridentata*	—	—	—	—	1
Fish, *Ranzania* sp. juveniles	—	2	—	—	—
Fish, *Gnathanodon* sp. juveniles	—	1	—	—	—
Fish, unidentified larvae and juveniles	—	2	—	—	—
Fish, unidentified bones	—	—	1	—	—
Fish, unidentified scales	—	3	—	—	—
Parasitic or attached organisms					
Copepoda (caligoid), *Nesippus* sp.	—	—	—	—	1
Copepoda (caligoid), *Gloiopotes* sp.	—	—	—	2	—
Copepoda (caligoid), pandarid	—	—	—	1	—
Copepoda (caligoid), caligid	—	—	—	1	—
Fish, unidentified echeneid	—	—	—	—	1
Scraps					
Fish muscle or liver	1	—	—	2	—
Unidentified muscle	—	—	1	—	—
Squid skin (?)	—	—	—	1	—
Grapefruit fragments	—	1	—	—	—
Meat from galley	—	1	—	—	—
Empty	3	1	0	3	3
Total examined	4	7	4	9	8

is therefore probably opportunistic rather than a regular way of life. Little can be said of the incidence of scrap consumption in *Rhombochirus*.

Miscellaneous adaptations.—In addition to the differences in viscera and diet discussed above, two other aspects of echeneid biology were investigated. The first concerns the manner by which the parasite-feeding species obtain their prey, in brief, whether they are structurally modified for capturing the flattened, clinging "sea-lice" upon which they feed. In all species examined, the lower jaw projects beyond the upper so that its short canine and villiform teeth enter the snout profile (see Suyehiro 1942:217). A measure of the degree of prognathism was obtained by dividing the distance between the tips of the two jaws by the snout length. Excluding specimens shorter than 100 mm. (which all had greatly projecting lower jaws) this overbite averages 28 percent for *Remoropsis pallidus*, 25 percent for *Remoropsis brachypterus*, 17 percent for *Remora remora* and *Phtheirichthys lineatus*, and 12 percent for *Rhombochirus osteochir*. Not only does *Remoropsis* have from 50–100 percent greater overbite than the other genera, but its teeth are also longer and could seemingly be brought to bear on the host's skin while attached by the sucker. It is thus conceivable that these fish obtain their parasitic food while attached to the skin of the host.

Fish and invertebrate plankton constituted the principal diet of *R. remora, P. lineatus*, and to a lesser extent, *R. brachypterus*. In several cases individuals were found with the alimentary tract crammed with one or two planktonic species indicating either selectivity in feeding or patchy distribution of plankters. As is shown in Table 2, *R. brachypterus* also fed upon ectoparasites, and Szidat and Nani (1951) and Maul (1956) found *R. remora* doing the same. These two species may be transitional with respect to diet, feeding upon plankton when it is abundant and taking parasites at other times. No ectoparasites were found in *P. lineatus*, but to this should be added the fact that none of the present specimens was attached to a living fish (Table 1). Of the two fish removed from longline buoys, the *R. remora* had an empty digestive tract whereas the *P. lineatus* had consumed a variety of planktonic organisms as well as scraps. The *P. lineatus* taken from a longline bait contained a single hyperiid amphipod.

Remoropsis pallidus is apparently largely dependent upon its hosts' ectoparasites as food, and as noted above, it may also feed upon remnants of its hosts' meals. Its lack of dark pigment and its propensity for dwelling in the branchial cavities of marlin are undoubtedly additional modifications towards a highly specialized existence. Perhaps echeneids tend to invade the bucco-pharyngeal regions of their hosts because of a concentration of parasites there; a similar explanation has been offered by Szidat and Nani (1951) to account for echeneids' temerity around the mouths of sharks.

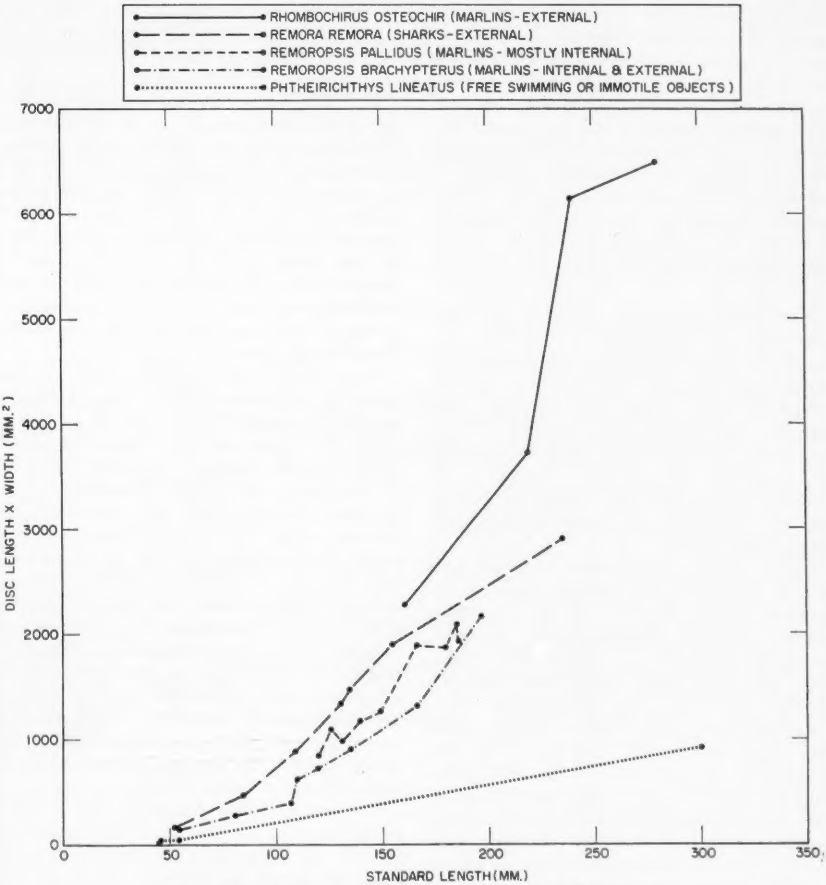


Fig. 1.—Echeneid disc size versus fish length and type of attachment to host.

It is difficult to relate the difference in viscera with that in diet between the plankton- and parasite-feeding species.

It will be noted from Table 1 that some echeneids were more or less host-specific, and the second question deals with structural modifications relating to this. The feature investigated was the sucking disc, with an attempt being made to relate its area to the type of host or attachment site. An approximation of the area of the elliptical sucker was obtained by multiplying its greatest length by its greatest width. Areas obtained in this way have been plotted against fish length in Figure 1. It can be seen that the fish with the largest sucker, *Rhombochirus*, attaches to the body skin of fast swimming marlins, whereas the one with the smallest sucking disc, *Phtheirichthys*, is free-swimming or attached to immotile objects (it is also known from barracuda and sea bass—Schultz, 1943; Smith, 1950). Species intermediate in sucker-size attach to relatively slow-swimming sharks or take refuge beneath the opercula of marlins. Presumably water flow and turbulence are less in the branchial cavity than on the outside of these hosts.

From the above discussion it is apparent that echeneids occupy at least three ecological niches. They are predators on zooplankton and the smaller nekton, commensals taking scraps from their host, and symbionts removing the host's parasites as food. These trends appear to have some systematic basis for they are reflected in morphology, host selectivity, and the attachment

site. The five species considered constitute a natural series ranging from the least host-dependent species to the most. At the primitive end of the scale is *Phtheirichthys lineatus*, and at the specialized end, *Remoropsis pallidus*. *Rhombochirus osteochir*, *Remora remora* and *Remoropsis brachypterus* are intermediates, with the first showing specialization in its ability to adhere, and the other two in tending toward parasite consumption.—DONALD W. STRASBURG, *U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Honolulu, Hawaii.*

THE EARLY LARVAL STAGES OF THE RED HAKE, *UROPHYCIS CHUSS*.—Confusion has existed for some time in the literature regarding the early larval stages of the red hake, *Urophycis chuss* (Walbaum). Although their identity is generally known, there is no work describing the sequence of early development of this species. This paper is intended to fill that lack and to summarize briefly the existing literature concerning the early developmental stages of this species.

Eggs and early larval stages of the red hake were first described from tow-net collections off Newport, Rhode Island, and Nahant, Massachusetts, as "species allied to *Motella*" (rockling) by Agassiz and Whitman (*Mem. Mus. Comp. Zool. 14(1):1–56,* 1885) Their illustrations (Pl. 12, Figs. 1–12) compare perfectly with our series.

Both Perlmutter (*N. Y. Conserv. Dept. Suppl. 28th Ann. Rept. (1938), 15:11–71,* 1939) and Pearson (*U. S. Fish and Wildlife Serv., Fish. Bull. 50(36):79–102,* 1941) expressed the belief that the specimens illustrated in Kuntz and Radcliffe (*Bull. U. S. Bur. Fish. 35:87–134, figs. 61–65,* 1915–1916) as butterfish were in reality red hake. Comparing these figures with our own leads us to concur with Perlmutter and Pearson.

The eggs of the red hake were positively identified by Bigelow and Welsh in 1912, aboard the *Grampus* in Ipswich Bay. In 1916, at Gloucester, W. W. Welsh hatched out red hake eggs taken from ripe fish. Some camera lucida drawings by Welsh are reproduced by Bigelow and Welsh (*Bull. U. S. Bur. Fish. 40(965):1–567,* 1925), Hildebrand and Cable (*Bull. U. S. Bur. Fish. 48(1938):505–642,* 1940), and again by Bigelow and Schroeder (*U. S. Fish and Wildlife Serv., Fish. Bull. 53(74):viii, 1–577,* 1953). Both the eggs and larvae are most certainly red hake.

Hildebrand and Cable (*op. cit.*) give an excellent description of the newly hatched larvae; however, material covering the period of the radical change in the pigmentation pattern (see below) is lacking.

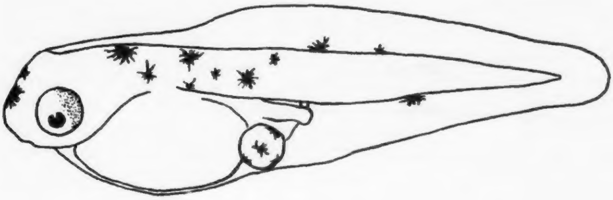
The following descriptions were made from larvae of known parentage. Ripe adult red hake were collected by otter trawl 36 miles south of Nantucket in 26–30 fathoms on August 9, 1956. The eggs were fertilized on board the vessel and subsequently brought to the laboratory at Woods Hole where they were allowed to develop. Hatching required about 36 hours at 70° F. (For a complete description of the egg, see Hildebrand and Cable, *op. cit:612–7, figs. 123–9*). At intervals, larvae were removed from the hatching jar and preserved in 5 percent formalin for further study. No attempt was made to feed the developing larvae, and the experiment was terminated 86 hours after hatching when the remaining few died.

Three hours after hatching (Fig. 1).—The newly hatched larvae average 2.04 mm. in length, ranging from 1.76–2.29 mm. The eye is lightly pigmented. There are one to three chromatophores on the forehead, about six scattered on the trunk, and a single chromatophore on the dorsal aspect of the body, directly above the vent. About halfway back on the tail is a pair of chromatophores, one on the dorsal mid-line, the other on the ventral mid-line, often extending a short distance out onto the finfold. The ventral chromatophore is usually slightly posterior to the dorsal. Posterior to the mid-point of the tail are one to three smaller chromatophores, generally dorsal to the mid-line. The pigmented oil globule is conspicuous and located just posterior to the yolk mass. The vent opens laterally near the base of the finfold, a rather consistent feature of gadid larvae.

Fifteen hours after hatching (Fig. 2).—The pigmentation of the 15-hour larvae remains essentially the same. However, the eye is more darkly pigmented, the yolk mass and oil globule are slightly reduced, and a small concentration of pigment on the dorsal surface of the developing gut becomes visible.

Twenty-two hours after hatching (Fig. 3).—The yolk mass and oil globule are further reduced and the eye is darkly pigmented. The chromatophores on the forehead have moved slightly posteriorly, and one or two large chromatophores appear on the nape. The peritoneum is more heavily pigmented than in the 15-hour larvae. In all other respects they are identical with the newly hatched individuals.

Thirty-eight hours after hatching (Fig. 4).—During the 16-hour period between 22 and 38 hours of development, a radical change in pigmentation occurs (compare Figs. 3 and 4). This change takes place concurrently with the completion of yolk sac absorption and appears to be quite rapid inasmuch as no intermediate stages were found among the 38-hour specimens. Also,



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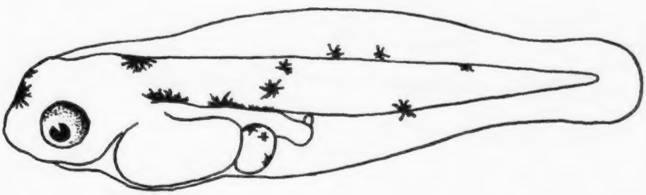

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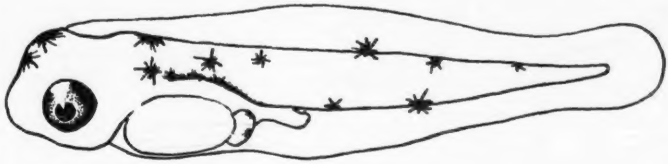

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Fig. 1.—*U. chuss* 3 hours after hatching, 2.1 mm.
Fig. 2.—*U. chuss* 15 hours after hatching, 2.2 mm.
Fig. 3.—*U. chuss* 22 hours after hatching, 2.1 mm.
Fig. 4.—*U. chuss* 38 hours after hatching, 2.2 mm.

of the many hundreds of larval *U. chuss* taken in surface net tows which we have examined, we have found no fish with an intermediate form of pigmentation. This provides evidence in favor of an equally rapid change under natural conditions.

A single large chromatophore is located on the nape; a single large dorso-ventral pair is found halfway back on the tail; and the peritoneum over the gut is heavily pigmented along its entire length. This basic pattern persists well beyond the 86-hour specimen illustrated (Figs.

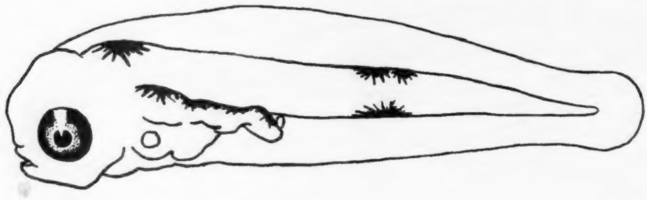

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Fig. 5.—*U. chuss* 44 hours after hatching, 2.2 mm.
Fig. 6.—*U. chuss* 62 hours after hatching, 2.2 mm.
Fig. 7.—*U. chuss* 68 hours after hatching, 2.1 mm.
Fig. 8.—*U. chuss* 86 hours after hatching, 2.2 mm.

5–8). For larger specimens see Hildebrand and Cable (*op. cit.*).

The fact that the 22- and 38-hour specimens bear little resemblance to each other and that intermediate stages have not been found in nature has no doubt led to confusion in identification.

The authors wish to thank Mr. Silas Barrows of Point Judith, Rhode Island, and the crew of the dragger *Portugal* for their assistance in the collection of the material.—David Miller and Robert R. Marak, *U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Biological Laboratory, Woods Hole, Massachusetts.*

TWO EIGHT-FOOT CUB SHARKS, *CARCHARINUS LEUCAS* (MÜLLER AND HENLE), CAPTURED IN CHESAPEAKE BAY, MARYLAND.—The measurements of a female *Carcharinus leucas* (Müller and Henle) 924 mm. long from Florida were recorded by Bigelow and Schroeder (*Fishes of the Western North Atlantic, I:337–346,* 1948). Recently, two cub sharks were captured in Chesapeake Bay. One male, 2,515 mm. (8 feet, 3 inches) long, that weighed 248 pounds was caught by Mr. Clayton Howard and crew in a haul seine at the mouth of the Big Annemessex River near Flatcap Point, Tangier Sound, Somerset County, Maryland, on July 28, 1958. The second male, 2,524 mm. (8 feet, 3-3/8 inches) long, that weighed 290 pounds, was captured by the Higgins Brothers in a pound net at Flag Pond, Calvert County, Maryland, on August 8, 1958. The salinity was 13–14 o/oo in the Big Annemessex and 10 o/oo at Flag Pond. The stomachs of both specimens were empty. The Big Annemessex shark thrashed violently on capture. The Flag Pond specimen bit several cownose rays, *Rhinoptera bonasus,* while being landed. Neither shark made any deliberate attemps of attacking their captors. Gaffing subdued the Big Annemessex specimen while a single blow on the head subdued the gentler Flag Pond specimen.

Measurements (Table 1) comparable to those listed by Bigelow and Schroeder (1948:339) were made with the assistance of David G. Cargo and Elgin A. Dunnington, Jr., shortly after each specimen was brought to the Chesapeake Biological Laboratory and are recorded here along with the proportional dimensions in percent of total length. In general, the two specimens fall within the reported weight range for 8–8½-foot specimens of between 250–375 pounds (Nichols and Breder *Zoologica 9(1):17,* 1927). Not only are these sharks twice the size reported by Bigelow and Schroeder (*op. cit.*), but notable changes in body proportions are evident with the increased size. The trunk height at origin of 1st dorsal is near ¼ its length to pre-caudal pits, while its breadth at pectoral origin is ½ to ⅔ this length. Snout length in front of mouth is ¼ of length of head to origin to pectoral. Longest gill opening is seven to eight (not two) times larger than the diameter of eye and is ⅔ or equal the distance between the inner ends of nostrils. The 5th gill slit is ½ to ¾ the distance between the inner nostril margins. The 1st dorsal vertical height is ½ to ⅔ distance from tip of snout to origin of pectorals. The 2nd dorsal is about ⅓ to ⅖ as long as 1st at base, and the free rear corner is ⅖ (instead of ½ to ⅔) as long as base. Pectorals are equal to or longer (not shorter) than head to origin of pectorals. Dermal ridges number five, with three prominent ridges, if sampled near the dorsal fin. Ventral denticles tend to possess three rather than five ridges.

TABLE 1

DIMENSIONS AND PROPORTIONS IN PERCENT OF TOTAL LENGTH FOR TWO CUB SHARKS, *Carcharinus leucas,* FROM CHESAPEAKE BAY

Item	Locality			
	Big Annemessex		Flag Pond	
	Measurement (in mm.)	Percent	Measurement (in mm.)	Percent
Trunk at origin pectoral				
a) breadth	308.1	12.3	266.7	10.6
b) height	444.5	17.7	508.0	20.2
Snout in front of outer				
a) nostrils	45.5	1.9	48.3	1.9
b) mouth	132.1	5.3	133.4	5.3
Eye: Horizontal diameter	16.0	0.6	12.7	0.5
Mouth				
a) breadth	336.6	13.4	292.1	11.6
b) height	104.9	4.2	162.6	6.4
Nostrils between inner ends	115.7	4.6	152.4	6.0
Gill opening lengths				
a) 1st gill slit	101.6	4.0	88.9	3.5
b) 2nd gill slit	111.3	4.4	98.6	3.9
c) 3rd gill slit	114.3	4.5	101.6	4.0
d) 4th gill slit	98.6	3.9	95.3	3.8
e) 5th gill slit	81.0	3.2	76.2	3.0
Dorsal				
a) vertical height	274.6	10.9	279.4	11.1
b) base length	292.1	11.6	279.4	11.1
Second dorsal				
a) vertical height	92.2	3.7	101.2	4.0
b) base length	111.3	4.4	110.7	4.4
Anal				
a) vertical height	103.1	4.1	105.7	4.2
b) base length	106.4	4.2	127.0	5.0
Caudal				
a) upper margin	639.8	25.4	676.4	26.8
b) lower anterior margin	304.8	12.1	317.5	12.6
Pectoral				
a) outer margin	482.6	19.2	507.5	20.1
b) inner margin	128.5	5.1	115.8	4.6
c) distal margin	439.7	17.5	444.5	17.6
Distance snout to				
a) $dorsal_1$	736.6	29.3	743.0	29.5
b) $dorsal_2$	1600.2	63.6	1600.2	63.5
c) upper caudal	1911.4	76.0	1926.0	76.4
d) pectoral	431.8	17.2	520.7	20.7
e) pelvic	1295.4	51.5	1290.5	51.2
f) anal	1624.1	64.6	1638.3	65.0
Interspace between				
a) 1st and 2nd dorsal	571.5	22.7	576.2	22.9
b) 2nd dorsal and caudal	196.9	7.8	215.9	8.6
c) anal and caudal	147.6	5.9	139.7	5.5
Distance origin to origin				
a) pectoral and pelvic	679.5	27.0	625.6	24.8
b) pelvic and anal	465.1	18.5	257.3	10.2
Total length	2514.6		2524.1	
Teeth	$\frac{13\text{-}1\text{-}13}{12\text{-}1\text{-}13}$		$\frac{13\text{-}1\text{-}13}{12\text{-}1\text{-}10}$	

The occurrence of these two specimens 61 and 83 miles above the mouth of Chesapeake Bay follows the pattern of this species often passing far upstream into brackish or freshwater. Bigelow and Schroeder (*op.cit.:342*) cite specimens captured from the Miraflores Locks of the Panama Canal and Lake Yzabal, Guatamala. Mansueti (*Md. Tidewater News 13(8):1,* 1957) tentatively identified a shark captured in the Patuxent River near Broomes Island, Calvert County, Maryland, as a cub shark. Five additional cub sharks were captured during 1956 in Chesapeake Bay between Galesville and Rock Hall, Maryland, (*Md. Bd. Nat. Res. 14th Ann. Rept., p. 32,* 1957). Gunter (*Copeia 1938(2):59*) cites a specimen captured 160 miles upstream in the Atchafalaya River near Simmesport, Louisiana, while recently Myers (*Copeia 1952(4):268–9*) notes a six-foot *Carcharinus leucas* captured 2,300 miles up the Amazon River in Peru. The recent presence of this species which hitherto has been reported only as a stray or uncommon in New Jersey and off Woods Hole (Fowler, *Rep. N.J. Mus. (1907):12,* 1908; Nichols, *Bull. Amer. Mus. Nat. Hist. 37:873,* 1917; *Copeia 1925(140): 21*; Nichols and Breder, *Zoologica 9:16,* 1927) suggests that it is a southern form which is perhaps extending its range northward with warming water temperatures.—FRANK J. SCHWARTZ, *Maryland Department of Research and Education, Solomons, Maryland. Contribution from the Chesapeake Biological Laboratory No. 118.*

OCCURRENCE OF BUTTERFLY FISH IN MISSISSIPPI SOUND.

—On August 10, 1958, two butterfly fish, *Chaetodon sedentarius* Poey and *Chaetodon ocellatus* Bloch, total lengths 85 and 80 mm., respectively, were speared by the writers while skin diving inside Ship Island, 3½ mi. from the west end. These were found darting among piles of rock at a depth of about 7 feet. During the summer this water has average salinities of about 28 ppt. and temperatures of 29°C.

Butterfly fishes are not uncommon in this area although they have not been reported before. At the time these fish were speared, six were seen in the same area. On August 7, several were seen by the authors around an old wreck at the west end of the island, and they have been sighted several times since. One small *C. ocellatus* was taken in August, 1957, by Dr. Hurst H. Shoemaker and his marine vertebrate zoology class.

Butterfly fishes have not been previously reported from the north-central part of the Gulf, and previous records are from Florida and Mexico. There is one report of *C. ocellatus* from south Texas by Baughman (*Copeia 1947(4):280*). The northernmost records of these two species in the Gulf of Mexico were reported by the U. S. Fish and Wildlife M/V *Oregon. C. ocellatus* was reported 29°37.3′ N. near Cape San Blas, Florida, and *C. sedentarius* was reported 28°55′ N. in open Gulf waters. Ship Island is 30°14′ N. which extends the range of *C. sedentarius* 139 miles north to the northern Gulf.

These specimens are located in the collection of the senior author.—RICHARD A. COLLINS, *Gulf Coast Research Laboratory, Ocean Springs, Mississippi,* AND ROBERT E. SMITH, *University of Alabama, Tuscaloosa, Alabama.*

OFFSHORE OCCURRENCE OF LARVAL SILVER MULLET, *MUGIL CUREMA*, IN THE WESTERN GULF OF MEXICO.

—Much has been written in recent years concerning the place of spawning of the American mullets of the genus *Mugil*. Evidence presented by Broadhead (*Florida State Bd. Conserv., Tech. Ser. 7:21,* 1953), Arnold and Thompson (*Copeia 1958(2): 130*), and Anderson (*U. S. Fish and Wildlife Serv., Fish. Bull. no. 144,* 1959) indicates that the striped mullet, *Mugil cephalus* Linnaeus, spawns offshore. Anderson (*U. S. Fish and Wildlife Serv., Fish. Bull. no. 119,* 1957) summarized published data and presented new records which showed that the silver mullet, *Mugil curema* Valenciennes, spawned offshore in the Atlantic, but he had no records for such an occurrence in the Gulf of Mexico. Hollister (*Zoologica 22(17): 271,* 1937) also found larval silver mullet (6–12 mm.) offshore over deep water, presumably off Bermuda. Various workers (Gunter, *Publ. Inst. Mar. Sci., Univ. Texas, 1(1):52,* 1945—Texas; Kilby, *Tulane Stud. Zool. 2(8):214,* 1955—middle Gulf coast of Florida; Joseph and Yerger, *Florida State Univ. Stud. no. 22, Pap. Oceanogr. Inst. no. 2:132,* 1956—northern Gulf coast of Florida) all state that the smallest silver mullet they collected inshore in the Gulf of Mexico were 23–24 mm. in standard length. This fact alone is good evidence for an offshore spawning by silver mullet, as discussed by Anderson (*op. cit.*) in noting similar Atlantic size records inshore. Further reason to conclude an offshore spawning for the species in the Gulf as well as the Atlantic is evidenced by the first known series of offshore-caught larval (as defined by Anderson, *op. cit.*) silver mullet from that area—which we report in this paper. In addition, they are the smallest reported from the Gulf of Mexico.

On May 25, 1954, at U. S. Fish and Wildlife Service M/V *Oregon* station 1074, Caldwell dipnetted a tiny school (only about 4 inches in diameter) of silver mullet as the fishes swam at

the surface near the drifting vessel. Station 1074 was located at latitude 24°00'N., and longitude 96°50'W., over 575 fathoms, some 55 miles from the nearest land. The air temperature was 78° F., the surface water temperature 77° F. The fish were collected at dusk. Fourteen of the specimens (7.2 to 9.8 mm. Standard Length) were deposited in the University of Florida Collections (UF 3913).

These specimens are of interest not only because they shed further light on the problem of the early life history of *Mugil curema*, but also because they more clearly define the sizes at which certain ontogenetic changes take place. Our fully-scaled 7.2-mm. specimen differs from the largest larval individual (7.0 mm.) described by Anderson, in that it has all of the fins and their rays fully developed and has a shallowly concave caudal fin, though the lobes remain well rounded. The shapes of the other fins also are more like juvenile silver mullet than those of Anderson's 7.0-mm. fish. The single nostril slit of our 7.2-mm. specimen has begun to pinch in midway along its length, and the double nostril of the juvenile has been fully accomplished in our 9.8-mm. individual. The preorbital bone is just beginning to appear in our 9.8-mm. specimen, though it has no serrations. Other characters of our specimens in general are more like Anderson's 14.5-mm. specimen than his 7.0-mm. fish.

Caldwell wishes to thank Stewart Springer for allowing him to participate in the cruise as an observer, then from the University of Florida, and we are grateful to Frederick H. Berry and Jack W. Gehringer for comments regarding this manuscript.—DAVID K. CALDWELL AND WILLIAM W. ANDERSON, *U. S. Fish and Wildlife Service, Brunswick, Georgia.*

A CASE OF PARTIAL ALBINISM IN THE FOUR-SPOTTED FLOUNDER, *HIPPOGLOSSINA OBLONGA*.—The four-spotted flounder, *Hippoglossina oblonga*, is a flatfish common to the New England coast. A partially albino specimen, 158 mm. in total length, was taken by otter trawl in 50 fathoms of water off the tip of Cape Cod, Massachusetts, in April, 1958 (position: 42°12' N. lat., 70°02' W. long.). This specimen was pigmented only on the anterior head region of the ocular side and on the fins. The blind side of the fish was entirely white as are normal specimens. Since the fish was found in a collection which had been on ice for a day, eye color could not be accurately determined. The eyes were dark, however, and there was no sign of pinkness. Morphologically, the fish appeared to be normal.

Ambicoloration, pigmentation on both eyed and blind sides, has been recorded for several specimens of *H. oblonga* (Gudger and Firth, *Amer. Mus. Novitates (885):1–9*, 1936; Bigelow and Schroeder, *U. S. Fish and Wildl. Serv., Fish. Bull. 53:270*, 1953). Partial albinism has been recorded in *Paralichthys*, a closely related genus (McKeever, *Calif. Fish and Game 44:171*, 1958). The Cape Cod specimen, however, is the only known reported case of partial albinism in *H. oblonga*.

True albinism, the complete absence of pigmentation, is apparently rare in flatfishes (Norman, *A Systematic Monograph of the Flatfishes, Vol. 1, Brit. Mus. Nat. Hist.*, 1934). Partial albinism, though, is by no means uncommon, and cases have been recorded for a large number of flatfish species.—FRED E. LUX, *U. S. Fish and Wildlife Service, Woods Hole, Massachusetts.*

THE ICHTHYOFAUNA OF THE LOWER RIO GRANDE, TEXAS AND MEXICO.—The known information on the fishes of Texas and the Rio Grande Basin was reviewed by Evermann and Kendall (*Bull. U. S. Fish Commission, 57–126*, 1894). Only scattered reports, such as those of Fowler (*Proc. Acad. Nat. Sci. Phila. 242–9*, 1904), Knapp (*Ragland Studio, Brunswick, Ga.*, 1953), and Hubbs (*Texas Jour. Sci. 6:277–91*, 1954; *Southwest. Nat. 89–104*, 1957), have appeared subsequently. The fish fauna of other parts of the Rio Grande basin has been reported recently by Guerra (*thesis, Univ. Texas*, 1952), Knapp, Hubbs, and Hubbs and Springer (*Texas Jour. Sci. 9:279–327*, 1957).

In light of recent collections, one of the early publications purporting to concern Rio Grande ichthyofauna (Jordan, *Bull. U. S. Geol. Survey, 4:397–406* and *663–7*, 1878) has been shown to be based on a collection erroneously labelled as being from "Brownsville, Texas" (Hubbs, *op. cit.*, and Miller, *Occ. Pap. Univ. Mich. Mus. Zool. 508*, 1955).

Nomenclature follows that of Moore (*Vertebrates of the U. S.*, 1957), except that *Chaenobryttus gulosus* replaces *C. coronarius* (Bailey, *Iowa Fish and Fishing, 3rd ed.*, 1956).

Beginning in December 1953, and continuing until February 1955, collections were made by me and friends at forty-five stations (Fig. 1) spaced at approximately 10-mile intervals in the lower Rio Grande, which is here defined as that segment between the mouth of the Pecos River and the Gulf of Mexico. Other specimens were gathered at three stations by Clark Hubbs and Kirk Strawn, at six stations by L. V. Guerra, and at six stations by various individuals. A total of 60 stations are represented.

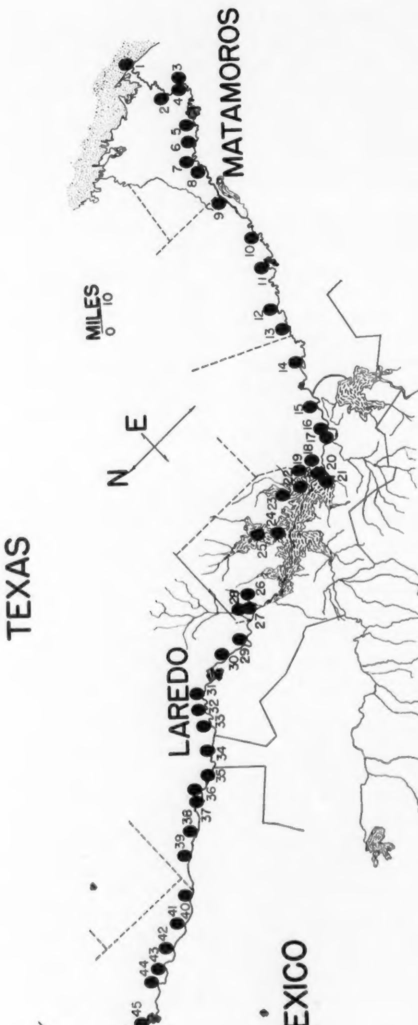

Fig. 1.—Map of collecting stations in lower Rio Grande.

Minor tributaries are included; however, no records are herein listed for major tributaries such as the Devil's, Salado, Alamo, and San Juan. Conditions include post-flood and drought and impoundment as well as the normal.

A 25-foot bag seine and Common Sense minnow seines were used in collecting to maximum depths of five feet.

Fifty-four species and one hybrid were found, of which 42 were prevalent in certain regions or tributaries only. There was a gradual change in the fauna along the river with one exception. A distribution break occurred between Brownsville and a site nine miles east of the city. It is assumed that sufficient salinity existed east of this point during this survey to term the waters brackish, and this condition constituted a major ecological barrier.

Only 12 species were truly cosmopolitan in their freshwater distribution. These adaptable forms which could be found in most of the freshwater stations were *Lepisosteus osseus, Dorosoma cepedianum, Astyanax fasciatus, Carpiodes carpio, Hybopsis aestivalis, Notropis jemezanus, Notropis lutrensis, Hybognathus placitus, Ictalurus furcatus, Gambusia affinis, Aplodinotus grunniens,* and *Cichlasoma cyanoguttatum.*

Of the 11 forms taken at the mouth of the river, five, *Galeichthys felis, Polydactylus octonemus, Eucinostomus argenteus, Gobionellus boleosoma,* and *Citharichthys spilopterus,* were not collected again. Brackish water inhabitants of the Rio Grande include *Elops saurus, Anchoa mitchilli,* and *Micropogon undulatus.*

The lower river region had seven freshwater forms that were not collected farther upstream. *Signalosa petenensis* and *Menidia beryllina* range from Webb County downstream; *Lepisosteus spatula* and *Cyprinodon variegatus* downstream from Zapata County; and *Mollienesia formosa, Mugil cephalus,* and *Gobiomorus dormitator* downstream from Starr County. Of these, only *Mugil cephalus* had a distribution that extended into the brackish waters and the mouth of the Rio Grande.

Three members of the genus *Lepomis, L. cyanellus, L. macrochirus,* and *L. megalotis,* were collected only in the central part of the river system during this survey.

The upper, northwestern part of the river contained 11 species, seven of which did not extend throughout the freshwater. These are *Rhinichthys cataractae* which dropped out in Webb County; *Pimephales vigilax* and *Pylodictis olivaris,* in Zapata County; *Ictalurus punctatus,* in Starr County; and *Notropis braytoni* and *N. buchanani* in Hidalgo County.

Nine species were seined only in the creeks included in this survey. Although the fish often were caught at more than one station, with two exceptions, they were taken in one creek only. The forms are *Notropis proserpinus, Dionda episcopa,* and *Etheostoma grahami,* which were found in three stations in San Felipe Creek; *Dionda diaboli* in Las Moras Creek; *Chaenobryttus gulosus,* Pinto Creek; *Pomoxis annularis,* Arroyo Dolores; and *Lucania parva,* Arroyo Tigre (twice). The two exceptions are *Notropis amabilis* which occurred in San Felipe, Pinto, and Las Moras Creeks and *Ictalurus melas* which was taken in Arroyos Dolores and Salado.

An immature *Moxostoma congestum* was collected from the river at a station made at the mouth of Tesquesquite Creek. *Notropis venustus* was caught in Val Verde County only, in two collections in San Felipe Creek as well as in one station in the river which constitutes the only record of this species in Mexico.

Occasional catches at widely scattered points in the river as well as in its tributaries were made of *Mollienesia latipinna* and *Micropterus salmoides.* Infrequent collections were made of *Cyprinus carpio, Anguilla rostrata, Lepomis punctatus, L. microlophus,* and *Dormitator maculatus.*

Individual species distribution maps are on file with the ADI Auxillary Publications Project, Library of Congress and any party interested may obtain a copy (Document No. 6005) by paying for a small photoduplication charge.

Following is the list of collection stations where each species was seined. *Lepisosteus spatula* 5–6, 17, 19, 23; *L. osseus* 7, 15, 17, 33–6, 38–9, 41, 45–6, 51–2, 59; *Elops saurus* 1–3; *Signalosa petenensis* 3–5, 7–19, 22–3, 29–37; *Dorosoma cepedianum* 1, 3–6, 8–19, 22–4, 26, 28–36, 46, 48, 51, 57–8. *Anchoa mitchilli* 1–2; *Astyanax fasciatus* 2–20, 22, 24–7, 30–6, 40–2, 45–9, 53–60; *Carpiodes carpio* 3–9, 11, 13–8, 20, 22, 29–38, 41–2, 46–8, 51–2; 57, 59; *Moxostoma congestum* 48; and *Cyprinus carpio* 42, 51, 58. *Hybopsis aestivalis* 4, 7, 9–13, 16, 22, 27, 29–31, 33–41, 43–48, 52, 57–8, 60; *Rhinichthys cataractae* 36–7, 41, 44, 52, 57; *Notropis jemezanus* 2–4, 6–19, 27, 29–48, 52, 57, 59–60; *N. amabilis* 49–50, 54–6; *N. braytoni* 11, 16–7, 20, 22, 24, 27, 29–48, 51–2, 58–60; *N. venustus* 54, 56–7; *N. lutrensis* 9, 11–4, 16, 18–9, 22, 25–38, 40, 42–48, 51–2, 54, 56–8, 60; *N. proserpinus* 54–6; *N. buchanani* 13, 20, 29, 31, 33–4, 36–7, 42, 45, 48, 58; *Dionda episcopa* 54–6; *D. diaboli* 49; *Hybognathus placitus* 3–11, 13, 15–7, 20, 22, 27, 29–30, 33–6, 38, 41–2, 44, 47–8, 58; *Pimephales vigilax* 22–3, 25, 29–34, 36–8, 40, 45–8, 57; *Galeichthys felis* 1; *Ictalurus punctatus* 16, 27, 34, 38–48, 52–3, 55–9; *I. furcatus* 6–8, 15, 18, 27, 34–6, 38–40, 43, 45, 51–2, 57–60; *I. melas*

26, 28. *Pylodictis olivaris* 27, 38–47, 57–8, 60; *Anguilla rostrata* 33; *Lucania parva* 22–3; *Cyprinodon variegatus* 2, 5–6, 9, 11–2, 14–5, 26; *Gambusia affinis* 4–8, 10–7, 19–23, 25–34, 36–7, 40, 42–3, 45–52, 54–6; *Mollienesia formosa* 4, 12–5, 17; *M. latipinna* 10, 26, 28, 49; *Mugil cephalus* 1–11, 16; *Menidia beryllina* 3–7, 10–20, 22–6, 28–36; *Polydactylus octonemus* 1; *Micropterus salmoides* 15, 45, 48–50; *Chaenobryttus gulosus* 50. *Lepomis cyanellus* 20, 22–4, 26–9, 31, 33–4, 36–7, 45, 47; *L. punctatus* 27; *L. microlophus* 33, 50; *L. macrochirus* 13, 17–8, 20, 24, 29–30, 32–4, 36–7, 45, 48–50; *L. megalotis* 28, 37, 50, 52; *Pomoxis annularis* 28; *Etheostoma grahami* 53–55; *Eucinostomus argenteus* 1; *Aplodinotus grunniens* 6, 9, 13, 15–8, 30, 37–40, 42, 51; *Micropogon undulatus* 1–3; *Cichlasoma cyanoguttatum* 5, 11–8, 24, 26, 36, 41, 44–6, 49–50, 52–7; *Gobionellus bolesoma* 1; *Dormitator maculatus* 3; *Gobiomorus dormitator* 2–3, 9, 21; and *Citharichthys spilopterus* 1.

The lower Rio Grande from Webb County to the Gulf of Mexico dried up at Laredo, Texas, from June 5, to 8, 1953, (*Facts on File 13(661): 213,* 1953) and the river stopped flowing for the first time in recorded history. Collections made in this region during the following summer showed that many kinds of fishes were abundant, with the disaster having no apparent undesirable or severe after effects; however, there are few pre-drought collections available for comparison.

Large numbers of species and individuals were captured in the upper portion of the river during a field trip taken a month after a flood that rose to record heights and almost wiped out the cities of the Del Rio-Villa Acuna and Eagle Pass-Piedras Negras area in the upper, northwestern river segment. During this flood, the river at Laredo, Texas, which normally is 12 feet crested at 62.21 feet on June 30, 1954 (*The Laredo Times, p. 1,* July 1, 1954). The flood raged during June 27, to July 1, and washed away the International Bridge at Laredo.

Most of the fish having publication records from the lower Rio Grande were not collected in their listed locality during this survey. *Dionda episcopa, Notropis amabilis,* and *Astyanax fasciatus* were taken in San Felipe Creek but not *Lepomis cyanellus* or *L. megalotis; Lepomis cyanellus* but not *L. megalotis* was collected at Eagle Pass; *Cichlasoma cyanoguttatum, Astyanax fasciatus* and *Gambusia affinis* were found at Brownsville-Matamoros but not *Lepomis macrochirus, Pimephales vigilax, Notropis lutrensis, Ictalurus furcatus, Mollienesia latipinna,* or *Aplodinotus grunniens*; and *Micropogon undulatus* and *Gobionellus bolesoma* were caught at the mouth of the Rio Grande but not *Ictalurus furcatus, Aplodinotus grunniens, Lutjanus apodus, Caranx hippos, Dormitator maculatus, Gobiomorus dormitor, Astyanax fasciatus,* or *Anguilla rostrata.*

I wish to express my appreciation to the persons who helped collect: Desiderio Treviño, Sr., David Ferries, Ralph Axtell, J. R. Tamsitt, and R. M. Robinson; to the following for making collections available: Clark Hubbs, Kirk Strawn, and L. V. Guerra; and to Clark Hubbs and L. S. Dillon for reading the manuscript.—DORTHEA TREVIÑO ROBINSON, *Texas Engineering Experiment Station, College Station, Texas.*

BURROWING ACTIVITIES OF THE LARVAL LAMPREYS.—Since the appearance in 1950 of Applegate's work on the sea lamprey in Michigan (*U. S. Fish and Wildl. Serv., Spec. Sci. Rept.; Fish, No. 55*) and the subsequent development of means to control lampreys in the Great Lakes, biologists have accumulated much additional information on adult lampreys. Larval lampreys, however, are difficult animals to observe in the field, and many facets of their behavior are still unknown. While working with the U. S. Fish and Wildlife Service, I kept ammocetes in captivity, and was able to observe their burrowing activities.

Normally, an ammocete released in water over a mud bottom swims rapidly downward until it hits the substratum, head down, with its body in a vertical position. A continuation of this swimming action pushes the anterior end of the body into the soft bottom material an inch or more. At this point, the swimming action stops, and the body of the larva lies over on the surface of the mud. From this position it disappears smoothly down out of sight into the bottom material without any further undulation or noticeable muscular activity. My curiosity as to how the larval lamprey accomplished this movement was finally satisfied after I observed the following procedure:

When I was holding larvae in captivity as previously described (Sawyer, *Copeia, 1957(3):244*), I transferred some to gallon jars. Because ammocetes exhausted themselves trying to burrow into the bottom of the containers, a wad of cotton was provided as a substratum. This seemed to be a satisfactory substitute for mud, and the dark-colored animals were easily observed against the white background. When released in these containers, which held about 3 liters of water, the larvae swam rapidly to the bottom, began their side to side whip-like movements which forced their anterior ends into the cotton about an inch. Then this movement

stopped, and the oral hood began to function. The ammocete warped its hood to one side or the other, and cast about rapidly, selecting the best route through the apertures in the cotton. At times, the mobile, lip-like structure was flared out at an advantageous point to serve as an anchor against which muscular contraction pulled. The flexibility of the oral hood was very great. It was folded in from side to side to make a sharp point which could be inserted through a tiny hole, or it was flared out to the right or left to serve as an anchor much in the same manner as the foot of a bivalve. Simultaneously, it appeared that the larvae used the loops of their bodies to push against their substratum similarly to the horizontal undulatory movements of a snake (Schmidt and Davis, *Field Book of Snakes of the United States and Canada, p. 47*, 1941). As the oral hood constantly sought the most easily traversed route through the cotton and held when necessary or continued to probe, the myomeric muscles of the trunk pushed against the irregularities of the cotton. Thus the tail end of the ammocete was gradually and smoothly drawn into the bottom material. Wriggling activity continued until the animal was well embedded within the cotton. At this point most forward progress stopped. The oral hood, however, often continued its movements and from time to time the whole body was advanced a little. The ammocete remained in this position for some time, appearing to rest after the strenuous burrowing activity. Larvae always preferred to be within the cotton, rather than just under it. Even when feeble as a result of treatment with chemicals they attempted to re-enter the substratum if they had wriggled out of it.—PHILIP J. SAWYER, *Department of Zoology, University of New Hampshire, Durham, New Hampshire.*

Herpetological Notes

CLOSURE OF THE NOSTRILS IN THE ATLANTIC LOGGERHEAD AND OTHER SEA TURTLES.—Among the adaptive modifications of terrestrial vertebrates that have become highly aquatic are devices that prevent water from entering the respiratory passages. Many examples could be cited in mammals and a few reptiles, but little attention has been paid to the method by which turtles meet this problem. Hoffmann (*In* Bronn's *Klassen und Ordnungen des Thier-Reiches, Band 6, Abtheilung 3*, 1890.) made no mention of any adaptions to prevent the entrance of water in his description of the nasal passages of several turtles, including the hawksbill and leatherback. Hansen (*Science 94: 64*, 1941) specifically states that narial valves are not present in turtles. McCutcheon (*Physiol. Zool. 16:255–69*, 1943), in a study of respiration of the diamond back terrapin (*Malaclemys terrapin centrata*), demonstrated that the glottis is tightly closed at all times except during expiration and inspiration, and that air is held in the lungs at greater than atmospheric pressure between periods of breathing. He also found that the glottis is held closed in a loggerhead. This would, of course, keep air in and water out of the lungs. But apparently it is not the whole mechanism in the highly adapted sea turtles. Legendre (*Comp. Rend. Soc. Biol. Paris 139:892–894*, 1945), in studying frequency of surfacing of a loggerhead, casually stated that the turtle closed its mouth and nostrils at submergence. During a stay at the Marineland Research Laboratory, Marineland, Florida, in the spring of 1955, I too was able to observe regular closure of the nostrils in the Atlantic loggerhead (*Caretta c. caretta*), but under different circumstances.

When these turtles were moving about under water near a porthole of their large tank, I could see that the nostrils were open and that the floor of their mouth moved slowly up and down (Fig. 1 A). The lower jaw also moved slightly. Presumably the turtles were passing water through the nostrils for olfaction, for McCutcheon (*op. cit.*) has demonstrated that such throat movements are olfactory in other species. When these turtles were sleeping on the bottom, or were obviously at rest, there was no such movement, and the nostrils were closed. The tank contained 9 loggerheads, and this was true every one of the numerous times that any of them was observed at rest. A similar phenomenon was observed twice in the ridley (*Lepidochelys olivacea kempi*), and twice in the green turtle (*Chelonia m. mydas*). Closure occurred part way within each nostril, and resulted from the meeting of bulges from the laterodorsal and medioventral walls of the nasal passages (Fig. 1 B). The laterodorsal wall especially bulged toward

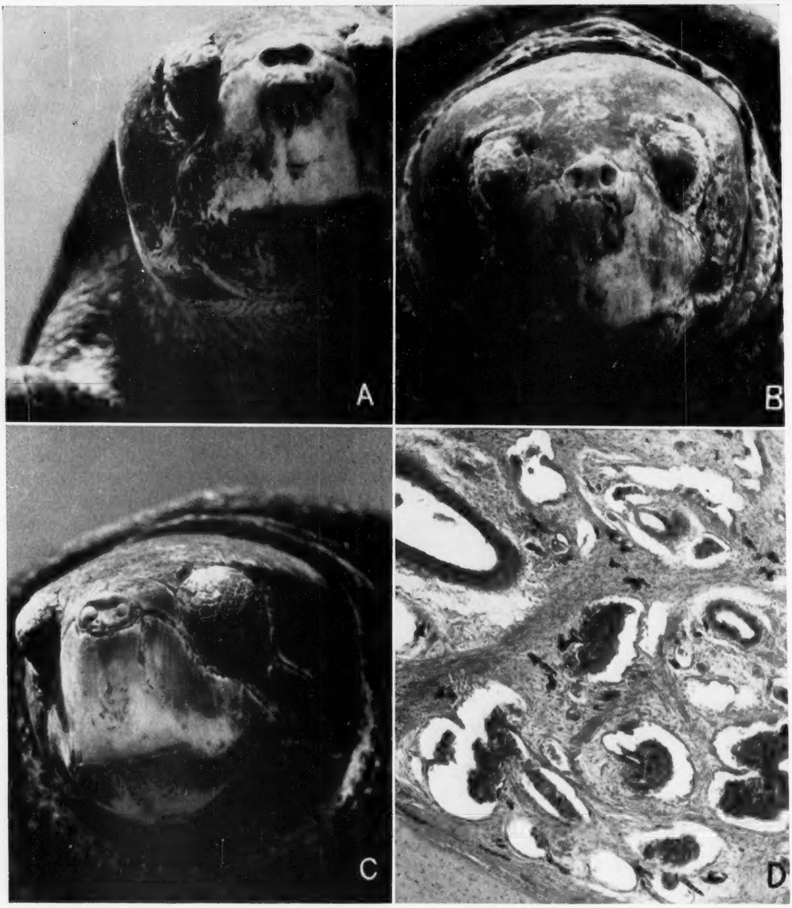

Fig. 1.—Photographs of the nose of loggerhead turtles. A, an active individual showing open external nares. B and C, two individuals at rest showing the closure of the external nares. D, a high power photomicrograph of a portion of the nasal mucosa to show the network of blood vessels. This is a frontal section through the medial side of the nasal passage; a section of the cartilaginous nasal septum can be seen in the lower left corner; the epithelium lining the nasal passage is not included but would lie a distance from the upper right corner.

the other, and in one individual even protruded slightly at the surface (Fig. 1 C).

One case was particularly interesting. A loggerhead was at rest on the bottom, the floor of its mouth was still, and its nostrils were closed. A diver cleaning the inside of the portholes brushed against the turtle and roused it; thereupon the nostrils opened and the floor of the mouth began moving up and down. This case was not timed, but on three occasions when loggerheads began stirring of their own accord, opening of the nostrils was timed with a stop watch. It took 23 to 45 seconds from the time the folds began moving apart until the nostrils were judged to be wide open.

Gross dissection of the nasal passages of two loggerheads revealed no pocket-shaped or flap-shaped valves, so another was sacrificed and the area of closure was cut out and examined histologically. All sides of the nasal passages in this region were lined with a stratified squamous epithelium, beneath which was a layer of vascular connective tissue (Fig. 1 D). Glands were absent. The connective tissue was exceedingly vascular, venules in particular were abundant. These vessels coalesced, forming a network. In places, small cavernous spaces, partly broken up by trabeculae, were present. The whole resembled erectile tissue, but the cavernous spaces were neither as large nor as numerous, and it

was not clear whether on not the trabeculae contained smooth muscle. Hoffmann (*op. cit.*) made no mention of such a vascular plexus in the nasal passages of the hawksbill, but his sections were taken through more posterior parts of the nose.

Such a vascular network can have little to do with warming the air passing into the lungs in a poikilotherm, as is believed to be the role of a somewhat similar plexus in parts of the human nose. Probably this plexus is the mechanism for closing the nostril in sea turtles, for when it became engorged with blood it would swell and the opposite sides of the nasal passages would approach each other.

A closure of this nature obviously prevents water from entering the respiratory passages, but the question arises as to why this is necessary when turtles are at rest, if closure of the glottis is sufficient at other times, as it usually must be. I saw no indication that the nostrils are regularly closed during submergence, as Legendre (*op. cit.*) noted. Again McCutcheon's study (*op. cit.*) throws some light on this question. He found that a mechanical stimulation, such as tapping the shell, caused the glottis to open. Moreover, sensitivity to stimuli increased as the time following inspiration increased. He also found that general muscle tonus was lowered during prolonged apnea. Sea turtles at rest on the bottom for a prolonged period therefore might be hypersensitive to stimuli that would cause the glottis to open reflexly, or they might have such low muscle tonus that the glottis would not be tightly closed. I suggest that the closure described here is an adaptation to prevent water entering or air leaving the respiratory passages under these conditions.

I wish to thank the staff of the Marineland Research Laboratory and Marine Studios for the opportunity to make these observations. In particular, I am indebted to Mr. Frank S. Essapian for taking the photograph shown in Fig. 1 C, and to Mr. Mickael Castagna for help with the preparation of the slides.—WARREN F. WALKER, JR., *Department of Zoology, Oberlin College, Oberlin, Ohio.*

THE GLIDING FLIGHT OF *HOLASPIS GUENTHERI* GRAY, A WEST-AFRICAN LACERTID.—During a herpetological expedition to Southern Nigeria we have had ample opportunity of studying the beautiful little lacertid lizard *Holaspis guentheri* Gray. This lizard is an inhibitant of the tree trunks in the tropical rain forests of West Africa. It is, however, not found in the closed forest, but only in clearings where the sun can penetrate. It is active by day, especially when the sun is shining, at which time it can be seen running up and down the trunk searching the crevices in the bark for insects.

One of us (A. S.) had repeatedly seen a *Holaspis* suddenly appearing on a trunk, as from nowhere, which led us to suppose that it was able to make short jumps like many geckos and agamas. In order to study its jumping ability, we decided to keep a specimen under constant observation for some time. An animal sitting high up on the trunk just under the crown of an oil palm was chosen for the purpose. For about half an hour it sat motionless, head downwards, then it started circling around, as if looking for something. In the binoculars we could see it turning its head from side to side. Suddenly it jumped off the trunk; and, to our great surprise, performed a perfect downward glide through the air, and landed securely, head upwards, on another trunk about 10 meters distant from the one it had left. The track of the flight was first rather steep, but during the last few meters it leveled out. There was a slight rise just before the landing. During the first part of the flight the longitudinal axis of the lizard almost coincided with the direction of the flight, but during the last part it carried its body more and more obliquely in the air until it at last stood vertically on its track, finally landing at reduced speed with its belly against the trunk and the head upwards.

The height of its starting and landing points and the horizontal distance between the trees were measured. The horizontal distance between the two trees was found to be 10.5 meters and the approximate length of the track was calculated to be 13.5 meters with a drop of 9 meters. The average slope of the track was about 42°. The whole performance gave the impression of being deliberate, since the animal was not in any way frightened by us, and it obviously aimed at the landing point from the start of the flight. There was no wind to help the flight.

Having ascertained this gliding ability in *Holaspis*, we have repeatedly seen it perform similar glides. It is therefore beyond doubt that such gliding flights form a normal feature in the behavior of *Holaspis*. Once it was observed to span a small river in this way, landing securely on a trunk on the other side. Another time the animal landed on the trunk of a fallen tree and immediately began running about in search of prey. The exactness of its aim and its ability to follow a staked course is shown by a case in which the animal landed on a small piece of loose bark projecting from the trunk. During one of the flights the animal was observed to curve its back in the horizontal plane, apparently in order to steer the flight.

Unlike the flying lizards (*Draco*) of southeast Asia, *Holaspis* has no striking morphological adaptations for gliding flight, which possibly explains why this ability has not been previously suspected, although it is able to flatten its body to an extraordinary degree. This ability is often used when the animal is basking in the sun on a tree trunk, and then its body may become almost circular in outline and flat as a coin. Although we have not so far been able to observe the body shape during the flight, it is a fair guess that the body is kept flat in order to increase the carrying surface during the flight. The tail of *Holaspis* is rather broad and flattened on the lower surface. Furthermore, it is provided with a row of large projecting scales on each side. These scales have been supposed to aid the animal's securing its hold when climbing on the bark (Schmidt and Inger, *Living Reptiles of the World,* 1958). This function is, however, extremely doubtful. First, the position of the enlarged scales is on the side and not on the lower surface, which would be more practical if they were to get a hold in the bark; second, *Holaspis* moves as easily downwards as upwards on the trunks; and third, when the animal is seen in profile on a trunk, it is often possible to observe that there is space between the tail and the bark, in other words, the tail is not pressed firmly against the bark. It seems therefore much more likely that during the flight the projecting scales serve to increase the carrying surface and the steering ability of the tail. Once during a flight a faint rattling noise was heard, which may have been caused by the air making vibrations in the projecting scales that are rather loose in the live animal. None of the numerous specimens collected by us has had a regenerated tail.

As far as we know, this is the first example of gliding flight in a lactertid and also the first time this ability has been demonstrated in any African lizard.—ARNE SCHIØTZ AND HELGE VOLSØE, *University College Ibadan, Nigeria, West Africa.*

BIRTH AND LITTER SIZES OF THE BLUE SPINY LIZARD *SCELOPORUS CYANOGENYS.*—A series of *Sceloporus cyanogenys* was collected on March 15, 1958, in Webb County, Texas. Seven females were gravid at the time of capture and were observed during the gestation period and birth of the young. The females were isolated from the males from the time of capture.

As the time approached for the birth of the young, the females were placed in individual observation cages to retain the small lizards and maintain accurate records for each female. These cages were periodically checked to ascertain the time of birth for each litter.

At birth, the young were surrounded by the fetal membranes which formed an oblong capsule. Measurements for four capsules were 12 × 20 mm.; 13 × 20 mm.; 13 × 21 mm.; and 14 × 20 mm. Within this membrane, the young lizard was curled up with the tail passing across the anterior end and folded back parallel to the body. The legs were also folded back parallel to the axis of the torso. Delivery was usually with the anterior end appearing first, although several were observed when the posterior portion of the lizard was presented first. The expulsion of the capsule was usually preceded by abdominal contractions which lasted from 15 to 60 seconds. Two individuals did not show any contractions, two had an average of three contractions lasting 15 seconds each, and the remaining three females varied in number and duration of the contractions.

Within 30 seconds, movements began that soon freed the head of the young lizard. After the head was through the membrane, from two to ten minutes were required for the lizard to emerge completely. One specimen was unable to rid itself of the amnion, and in fifteen minutes it had dried and effectively rendered the young lizard helpless.

The eyes were open within two minutes after birth and appeared functional immediately. After gaining their freedom, the young would remain motionless for several minutes to one hour. They would then move about the cage with agility and feed on ants and fruit flies that were placed in the cage.

During the labor and birth of the young, the adult females were sluggish and took little notice of activity outside the cage. Respiration increased. They would raise themselves with the forelegs, allowing the posterior portion of the body to remain close to the ground. The tail was curled up and around allowing the young to be born without any interference from this organ. The adult did not eat the membranes after the young had escaped, nor was any attention given to the newborn.

When first handled by the author, the young discharged clear liquid from the cloaca. In a few cases, a white solid material (presumably uric acid) was observed in the liquid.

No sexual dimorphism was observed in the young. The dorsal pattern is similar to the adults but much more vivid, more closely approximating the adult female in coloration and pattern. The ventral surface is pearly white with no dark spots. A ventrolateral patch of very light blue is present in both sexes. The dark nuchal collar varies from four to five scales in width on the lateral portions. The head

scalation is regular medially with irregular supraoculars, which is characteristic of the species as described by Smith (*Handbook of Lizards, p. 203*, 1946).

There is a series of light brown bands on the dorsal side, varying in number from five to six. These are separated by light bands one scale in width. Dark bands on the tail vary from 15 to 21. Single dark scales are scattered throughout the dorsal pattern, somewhat concentrated in vague rows, parallel and anterior to the white bands.

Axtell (*Herpetologica 6:80*, 1950) mentioned the young of a closely related species, *Sceloporus poinsetti*, which has six to seven black bands in the dorsal pattern on the young. The species also has from 10 to 12 dark bands on the tail. Young specimens of the same species observed by the author have four dorsal dark bands separated by light bands two scale rows in width. The dark spots scattered in the pattern of *cyanogenys* were not observed in the young of *poinsetti* which also differ in ventral coloration in having dark bands and spots on the anterior and gular portions.

Ramsey and Donlon (*Copeia 1949(3):229*) stated that *Sceloporus poinsetti* emerged at birth free of any membranous sac, but were able to "scamper about" as soon as they were dry. The average snout to vent length of six specimens was 31 mm. *S. poinsetti* born in our laboratory were encased in membranes at birth.

The first *cyanogenys* birth was recorded May 5, the latest, June 11. Table 1 depicts litter size, length of the females and date of birth for each litter. Table 2 gives the number of offspring for each adult female, average snout-vent length for males and females of each litter, minimum and maximum snout-vent length for each litter, average weight for males and females in each litter and minimum and maximum weight for each litter.

As noted in Table 1, the litter size increases as the size of the female increases. Female No. 42 was 88 mm. in length and gave birth to six young; Female No. 41 was 126 mm. in length and gave birth to 18 young. The other females represent intermediate steps in this trend. From the date of capture and the date of the first birth, the minimum gestation period of these lizards would be 52 days.

The largest newborn individuals were females. One from female No. 29 weighed .94 gm. No. 46 had a young lizard that measured 32 mm. in snout-vent length. It was also a female. The average weight of male newborn lizards was .82 gm.; the average snout-vent length of the newborn males was 29.7 mm., while the average length of the females was 29.5 mm. These figures indicate that the young are approximately the same size at birth, regardless of sex. In the total number of young, there was a predominance of females, 48 to 40 males.—Don Hunsaker II., *Department of Zoology, The University of Texas, Austin, Texas.*

TABLE 1

Female number	S-V length (mm.)	Litter size	Litter date
42	88	6	May 31
23	98	12	May 21
20	99	12	May 14
8	104	12	June 5
46	106	15	June 11
19	125	18	May 5
41	126	18	May 31

TABLE 2

Female number	No. offspring	Snout-vent length (mm.)		Weight (gms.)	
		Mean	Range	Mean	Range
19	8♂	29.75	29–31	.796	.77–.83
	10♀	29.3	29–30	.762	.66–.90
20	5♂	30.60	30–31	.804	.79–.82
	7♀	29.71	28–31	.828	.80–.91
23	5♂	29.40	29–30	.858	.84–.87
	7♀	29.80	29–31	.884	.84–.94
41	8♂	29.00	28–30		
	8♀	29.50	29–30		
42	3♂	30.00	29–31		
	3♀	28.50	28.5–29.5		
8	6♂	28.80	28–30		
	5♀	29.00	28–30		
46	5♂	30.60	29–31	.806	.77–.85
	8♀	30.38	29–32	.784	.72–.88

VARIATION IN THREE BROODS OF *STORERIA DEKAYI* FROM EASTERN LOUISIANA.—Although there are data available (Trapido, *Amer. Midl. Nat. 31(1):1–84*, 1944) on variation in *Storeria dekayi*, information on variability within individual broods appears to be lacking in the literature.

Three broods in the Tulane University (TU) collections were examined. Two of these, TU 16232, a brood of 12, and TU 17183, a brood of 11, are from New Orleans, and the third, TU 14020, a brood of 16, from Angie, Washington Parish, Louisiana. The female parent of each of these broods is of the subspecies *wrightorum*; the males were not seen. All snakes had been preserved at, or shortly after, birth.

In Tables 1 and 2, the symbol "½" indicates the marking for one side of the head in individuals having different markings on either side.

The number of ventral scales to, but not including, the anal varies from 116 to 133 (124.4 ± 0.80) in the males and from 124 to 147 (133.2 ± 2.136) in the females. The number of pairs of subcaudal scutes ranges from 48 to 65 (55.7 ± 0.90) in the males and from 43 to 58 (49.2 ± 1.213) in the females. Sample size is 39 (21 males, 18 females) for both counts. These do not differ from those reported by Trapido (*op. cit.*) for *Storeria dekayi wrightorum* from the coastal plain except in showing a slightly greater range of variation. This may be due in part to Trapido's sample sizes being under 20. The number of ventrals between the umbilical scar and the anal scute ranges from 7 to 14 (11.3 ± .0815). There is no departure from the 17–17–17 dorsal scale count. Supralabials are 7–7 in 35 specimens; three of TU 17183 have 6–7 and one TU 16232 has 8–8. Thirty-five of the snakes have 7–7 infralabials; two of TU 17183 have 6–7 and one has 7–6. The latter and one of the former are two of the three that have a 6–7 supralabial count. An 8–8 infralabial count is shown by one of the TU 16232 brood. In all, both sides of the head have identical temporal counts. Of the 39 specimens examined, only two from TU 17183 have a 1 + 3 count; the remaining 37 have the usual 1 + 2 count.

The sums of the corresponding ventral and caudal counts, a reflection of the total number of vertebrae, were graphed against the total length of the snakes. The correlation coefficient

TABLE 1

MARKINGS ON ANTERIOR TEMPORAL

	Solid	Horizontal Bar	Diagonal Bar	Spot	No Mark	Total
TU 16234	10	0	2	0	0	12
TU 17183	0	3½	4	2	1½	11
TU 14020	13½	0	2½	0	0	16
Total	23½	3½	8½	2	1½	39

TABLE 2

MARKINGS ON FOURTH LABIAL

	Anterior Edge Darkened	Ends and Top Darkened	Posterior Edge and Top Darkened	Solid	Clear	Total
TU 16234	½	7½	2	1	1	12
TU 17183	0	2	8	0	1	11
TU 14020	0	4	12	0	0	16
Total	½	15½	22	1	2	39

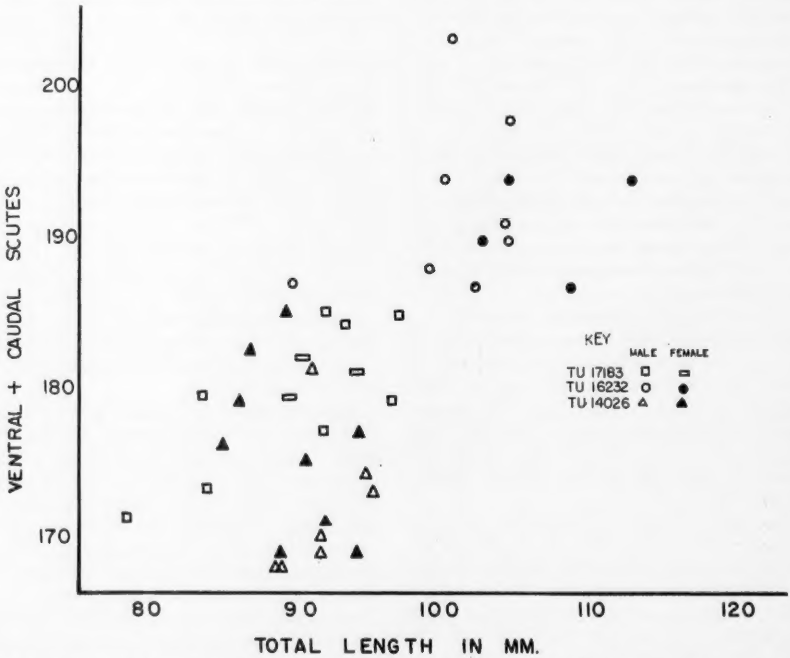

Fig. 1.—Correlation of length at birth with ventral plus caudal scute counts of *Storeria dekayi wrightorum* from eastern Louisiana.

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For 0.80, read 0.839
For 2.136, read 1.463
For 0.90, read 0.950
For 1.213, read 1.095

from these data is 0.71, well above the level given by Fisher (*Statistical Methods for Research Workers*, 1937) for 37 degrees of freedom at the one percent level of significance. If the length-scute count correlation in *Storeria* is biologically, as well as statistically, significant, it might indicate that the supposed selection against variants in snakes may be tied in with factors other than the body flexibility suggested by Inger (*Amer. Nat. 77:87–90*, 1943). In his work on the lizard genus *Aristelliger*, Hecht (*Evolution 6:112–24*, 1952) concluded that larger individuals were selected against by predators. Selective factors operating against smaller individuals were territorial dominance, sexual selection and availibility of food. The latter two factors, especially the last, may also affect snakes. —ROBERT C. FEUER, *Museum of Zoology, The University of Michigan, Ann Arbor, Michigan*

NOTES ON THE EGGS AND YOUNG OF THE SCARLET SNAKE, *CEMOPHORA COCCINEA* BLUMENBACH.—On September 12, 1956, a clutch of five eggs was found under moist humus in a pine woods one mile northwest of Richmond in Henrico County, Virginia. One egg was accidentally broken; the young snake lived but a few minutes. The remaining eggs were placed in a box with dirt and wet leaf mold.

The oval eggs were an off-color white and appeared soil-stained. Measurements were: mean length, 37 mm. (range 31–39 mm.); mean width at greatest diameter, 17 mm. (range 15–19 mm.); and mean weight 5.9 gr. (range 5.5–6.0 gr.).

Three eggs hatched within an hour on the afternoon of September 25th; the fourth, during the night. The snakes did not leave the shell until 12 to 15 hours later. One egg was opened prior to complete emergence to determine the position of the young. The snake was in three and one-half coils with the yolk stalk (22 mm. long) attached to the body 39 mm. from the tip of the tail. The yolk sac measured 13 mm. in diameter.

Total lengths of the snakes, taken the day after hatching, averaged 156 mm. (range 150–164 mm.). The pattern and coloration was that of the adult with the exception of soft pink-colored saddles rather than the characteristic red.

The snakes were kept until January 7, 1957, when they were placed in the University of Richmond Vertebrate Collection. Mean length at death was 162 mm. (range 157–170 mm.), an average increase of six mm. from time of birth.

Thanks are expressed to Mr. Roger Conant, Curator of Reptiles, Philadelphia Zoological Gardens, for his aid in identification of the young snakes.—WILLIAM S. WOOLCOTT, *Department of Biology, University of Richmond, Richmond, Virginia.*

OBSERVATIONS ON THE REPRODUCTIVE CYCLE OF THE SWAMP CHORUS FROG, *PSEUDACRIS NIGRITA*.—Numerous references detail aspects of the reproductive cycle of *Pseudacris nigrita*, and particularly full accounts of the western form *P. n. triseriata* were given by Wright and Allen (*Amer. Nat. 42:39–42*, 1908), Livezey (*Amer. Midl. Nat. 47 (2):373–81*, 1952), and Bragg (*Wasman Col. 7(4):149–68*, 1948). This paper contributes observations on ovulation, oviposition, egg complements, and morphology of eggs and jelly envelopes of *P. n. feriarum* and *P. n. kalmi* in New Jersey and of a *feriarum-triseriata* intergrade population in Jackson County, Illinois. This population has been discussed by the junior author (Rossman, *Herpetologica 15:38–40*, 1959). Preserved specimens are in the Newark Museum.

Ovulation.—Bragg (*Turtox News 19:10–2*, 1941; *Researches on the Amphibia of Oklahoma*, 1950), and Noble and Aronson (*Bull. Amer. Mus. Nat. Hist. 80:127–42*, 1942) presented contrasting views of anuran ovulation. According to Bragg, amplexus may precede ovulation, the clasp of the male presumably stimulating the release of ovulation-inducing hormone from the female pituitary. While "dependent ovulation" is known to occur in some mammals and birds, such a mechanism has not been proven for anurans, although Anderson (*Tulane Stud. Zool. 2(2):15–46*, 1954) reported ovulation following amplexus in *Microhyla carolinensis*. Noble and Aronson rejected this hypothesis for *Rana* when they found that non-ovulated *R. pipiens* would not accept amplexus. Such females obtained release by emitting warning croaks.

In order to examine this problem in *Pseudacris*, a series of 40 *feriarum-triseriata* intergrade females were collected by the junior author in Jackson County, Illinois, during February and March, 1958. The specimens were preserved on capture, and marked with individually numbered tags. At the same time, data were recorded indicating field conditions and whether the females were in amplexus. Preserved specimens were dissected to determine the condition of the reproductive organs.

Twenty-four females were not in amplexus, and of these, 18 had not ovulated, two were ovulating (eggs in ovaries, coelom, and a few in oviducts), one had ovulated (eggs in oviducts and uteri), and three were post-breeding. Sixteen females were taken in amplexus and of these, 15 had ovulated (10 with eggs in oviducts and uteri, four with eggs in uteri only, and

one post-breeding); the remaining specimen was ovulating and a few eggs had reached the uteri. Two of the amplexed females had partly discharged their egg complements prior to capture.

The above specimens were collected on February 26, and 28, and March 5, and 28, between 8:20 and 10:50 PM; (air from 36°–54°F, water from 41°–51°F). The February dates mark the beginning of local *Pseudacris* breeding activity. February 26, was the fourth day when diurnal air temperatures reached 60°F following five weeks of subfreezing weather; despite the fact that air and water temperatures on this date equaled or exceeded those on the March dates, vocal activity was limited to not more than six individuals at any one time, while the March choruses were deafening. Sixteen of the non-amplexed females were taken on February 26, and 28; no amplexed females were found and no eggs had been spawned. On March 5, eleven amplexed and six non-amplexed females were taken and of the latter, two had spawned, two were ovulating, and two had not ovulated. Only two non-amplexed females were collected on March 28; one of these had spawned and the other was ovulating.

The absence of non-ovulated females among those taken in amplexus clearly suggests that ovulation precedes amplexus. This conclusion is reinforced by the finding of non-amplexed females in which ovulation was in progress or had been completed. Fragmentary data on *kalmi* and *feriarum* follow a similar pattern. Wright (*Carnegie Inst. Wash. Pub. 197:III–VII, 1–98*, 1914) observed oviposition 20 and 90 minutes after the initiation of amplexus in *triseriata* indicating that the females were "ripe" when clasped. (Ovulation induced by pituitary implants required from 12 to 48 hours in *kalmi*.) On several occasions in the laboratory apparently continuous amplexus for three and four days of non-ovulated *kalmi* females did not induce ovulation. Similar occurrences were noted in *Hyla c. crucifer* and *P. brimleyi*, and it would appear that the clasp of the male alone does not stimulate ovulation in any of these forms. It is conceivable that the breeding call of the male or the intensity of breeding choruses could have a stimulating effect on ovulation, but this possibility remains to be investigated.

At the initiation of amplexus, therefore, ovulation is well advanced if not completed. It appears that spawning begins after the eggs have filled the uteri, although in one individual some spawning had obviously occurred before all of the eggs had cleared the oviducts. Unripe eggs remain in the ovaries after breeding. These range in size from very small unpigmented oocytes to pigmented ova equal to mature eggs in size. In non-ovulated *feriarum-triseriata* females the number of readily counted immature oocytes in the ovaries ranged from 28 to 45 percent of the number of mature eggs.

The Illinois data have a bearing on questions of "courtship" in *Pseudacris*, and the possibility of a mechanism effecting release in cases of mismating. Females enter the pools prior to ovulation, and apparently may not ovulate for several days or more. All but two of the Illinois series were in the water when captured; the exceptions were perched on vegetation above the surface. No marked difference in the distribution of amplexed and non-amplexed individuals within the breeding area was noted. Specimens were obtained from three pools, the largest more or less oval in shape and measuring approximately 75 feet by 50 feet on the major axes. The pools were partly bordered by woody growth consisting primarily of river birch (*Betulus nigra*), pin oak, (*Quercus palustris*), and sycamore, (*Platanus occidentalis*); water depth did not exceed 2 feet, and, in places, the larger pool was thickly grown with *Salix, Juncus,* and *Campsis* in addition to pin oak and cottonwood, (*Populus deltoides*).

Females, both ovulated and non-ovulated, were found throughout the pools and both were equally accessible to sexually active males. It has long been thought that initiative in pair formation might lie with the female, and, recently Martof and Thompson (*Behavior 13 (2–4):243–58*, 1958) demonstrated experimentally that amplexus occurs when the female approaches and makes bodily contact with a vocal male. (See also the review of salientian courtship and mating behavior by Jameson *Syst. Zool. 4(3):105–119*, 1955.)

Oviposition.—Livezey (*op. cit.*) and Wright and Allen (*op. cit.*) have described the spawning behavior of *triseriata* in Texas and New York, but several points require elaboration. Only observations that amplify previous accounts will be given. Most spawning is presumed to occur at night, "after midnight" according to Livezey, although diurnal spawning was observed in *triseriata* by Wright (*op. cit.*) and Bragg (*op. cit.*, 1948). Mated pairs of *kalmi* have been taken by day, *feriarum-triseriata* pairs in early afternoon. The Illinois series also indicates spawning in the early evening, since two of the amplexed females were apparently interrupted while laying, and a spent female taken about 10:00 PM was still in the clasp of a male.

Observations on the reflex-like behavioral responses of male and female during oviposition differ in *kalmi* from Livezey's description for

triseriata. Spawning was carefully observed on three occasions with captive pairs of *kalmi* and once in a mating of a male *kalmi* and female *H. crucifer*. A series of step-by-step, stimulus-response reactions by the male and female occur. These are very similar to those described by Noble and Noble (*Zoologica 2* (*18*):*416–55*, 1923) for *H. crucifer*.

The female *kalmi* seized a grass stem, twig, or other support with both hands and brought her longitudinal axis parallel to that of her mate and the support. The frogs now floated more or less free (Fig. 1, A). Initiation of spawning occurred when the female suddenly stretched her body while depressing her back to bring her rump upward against the underside of the male (Fig. 1, B). The latter immediately responded with a strong thrust downward and backward, hunching his body and then sliding his posterior ventral surface along the female's back (Fig. 1, C). At the conclusion of this presumably ejaculatory thrust, the male's rump was somewhat posterior to that of the female. During this action the female maintained her back in a slightly concave arch, but at its conclusion she abruptly swung her vent downward and forward away from that of the male, and the male resumed his pre-ejaculatory position (Fig. 1, D). The female's convulsive arching movement brought her vent nearly in contact with the support; up to about a dozen eggs were extruded within half a minute. While ovipositing, the female slowly pulled herself along, spreading her eggs in an irregular file along the support. The heels or inner surface of the tibia and feet may be used to manipulate the eggs as they are extruded. At the conclusion of this series of responses, the pair may perform again at the same spot, adding to the eggs already laid, or move to a new location. Rest intervals of varying length may intervene between ovipositions; observations on this aspect of spawning in *kalmi* do not differ generally from those given by Wright and Allen (*op. cit.*).

In comparison to the ejaculatory thrust of *H. crucifer*, which is a brief explosive movement downward and somewhat forward, the thrust of *P. n. kalmi* is more prolonged and is downward and backward. This minor difference may be related to *crucifer's* habit of laying eggs singly. A difference between female *P. n. triseriata* and *kalmi* is also indicated. Livezey apparently did not find a final concave "arching reflex" in female *triseriata*; he noted that "the position assumed would bring the vent away from the stem but, this was immediately corrected at the conclusion of the act by bringing one or both thighs and/or shanks toward the

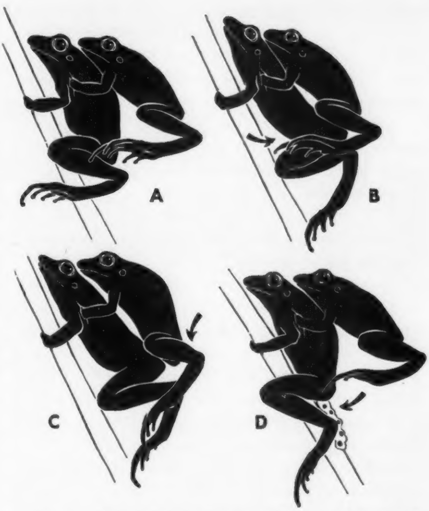

Fig. 1.—Sequence of response by male and female *Pseudacris nigrita kalmi* during oviposition. See text.

vent and pressing the extruded eggs onto the supporting object." While behavior in the *kalmi* matings was consistently the same, so few observations cannot exclude the possibility of individual variation approaching the behavior described by Livezey. The similarity of oviposition in *P. n. kalmi*, *H. crucifer*, and also *Hyla regilla* (Smith, *Science 92*(*2391*):*379–80*, 1940), suggests a recurring pattern in certain hylids that contrasts with spawning behavior in *andersoni*, *versicolor*, and probably additional species of *Hyla* (see Noble and Noble, *op. cit.*)

Eggs and egg complements.—Under natural conditions egg masses of *P. n. kalmi* and *P. n. feriarum* are usually found attached to twigs, grass stems, or similar supports near the surface and usually in shallow water. On one occasion a *feriarum* mass was found hidden beneath a thick mat of floating mosses. The individual eggs and their jelly envelopes are inclosed in a weak jelly forming a loose packet. The masses of the two New Jersey forms are similar, both vary in size but seldom exceed 2 inches in diameter. Sixteen field-collected *kalmi* masses contained from 8–143 eggs, (mean 40). These figures are close to those given by Livezey for *triseriata* (from 7–176 eggs, mean 43).

Eggs of *P. n. triseriata*, *kalmi*, and *feriarum* may be indistinguishable except for a larger jelly coat in *triseriata*. Sizes given by different authors vary somewhat but in New Jersey alone a variation of 10 percent or more occurs in different batches of *kalmi* spawn. The mean vitellus

diameter of Texas *triseriata*, given by Livezey as 1.27 mm., is almost identical with that of New Jersey *feriarum* (1.30 mm.) and *kalmi* (1.32 mm.). Our range for *feriarum* was from 1.24–1.38 mm., and *kalmi* from 1.29–1.34 mm.

Measurements of the vitelline capsule show wider variation, particularly after the yolk-plug stage when a considerable amount of water is absorbed into the perivitelline space. At the end of embryonic development, the diameter of the vitelline capsule may be twice that during the early cleavage stages.

Except for an unconfirmed observation of a double jelly envelope in *triseriata*, most authors describe a single envelope for *Pseudacris*. Its diameter in Texas *triseriata* was given by Livezey as 3.06–61 (mean 4.63 mm.). For New Jersey *kalmi* the mean was 3.10 mm., for *feriarum*, 3.35 mm. The jelly envelope is often weak and friable and difficult to measure accurately.

Geographic variation in total egg complements of *triseriata* is indicated in published data. Kansas and Oklahoma records of 1,081 and 1,459 eggs from single females were reported, while Wright (*op. cit.*) estimated from 500–800 eggs per female in western New York. Counts of ripe eggs in fifteen of the *feriarum-triseriata* intergrades were made for single ovaries and multiplied by two; mean 404, range 208–618. Ovarian counts of 13 New Jersey *kalmi* averaged 215, range 110–575, while laboratory spawnings produced 223 and 317 eggs. For six New Jersey *feriarum* the egg counts averaged only 130 but these included three small females with only 70, 74, and 80 ripe ova; the highest count was 310. The ovarian counts may be somewhat higher than the number of eggs spawned under natural conditions, since, as indicated above, a varying number of "mature" eggs is retained in the ovaries after breeding. The smaller egg complements of northeastern chorus frogs are comparable to those of *Pseudacris clarki* reported by Wright and Wright (*Handbook of Frogs and Toads*, 1949) as 150–175.

Summary.—Female *P. n. feriarum-triseriata* enter the breeding pools prior to ovulation, and no marked differences were found in the distribution of ovulated and non-ovulated females within breeding areas. Amplexus follows ovulation and it is likely that females take the initiative in pair formation. Spawning may occur at almost any time of the day or night but peak activity is probably nocturnal. Spawning behavior, at least in *P. n. kalmi*, follows a pattern very similar to that of *Hyla crucifer*, and consists of a series of stereotyped, reflex-like responses by male and female. The similarity of the eggs and jelly envelopes in *P. n. feriarum* and *P. n. kalmi* is consistent with the view that they are closely related; there is marked geographic variation in the size of total egg complements, the eastern forms laying fewer eggs. The need for further observation on the life histories of *Pseudacris* forms may be emphasized as an aid in the clarification of taxonomic problems in this complex group.—KENNETH L. GOSNER, *Newark Museum, 43 Washington Street, Newark, New Jersey,* AND DOUGLAS A. ROSSMAN, *Department of Biology, University of Florida, Gainesville, Florida.*

CALL STRUCTURE IN TWO GENERA OF AUSTRALIAN BURROWING FROGS.—All five species of *Heleioporus* (*eyrei, albopunctatus, australiacus, psammophilus,* and *inornatus*), and four of the five species of *Neobatrachus* (*wilsmorei, sutor, centralis,* and *pelobatoides*), are found in southwestern Australia. Within a genus each species may occur sympatrically with at least one other in some part of its range. Only one species, *N. pictus*, is not found in this region; it is restricted to the southeastern part of the continent. *H. australiacus* also occurs as a disjunct in southeastern Australia, and *N. centralis* is widespread across southern Australia (Main, Lee, and Littlejohn, *Evolution 12:224–33*, 1958). The general non-breeding biology of the adults of the southwestern species has been considered by Bentley, Lee, and Main (*Jour. Exp. Biol. 35:677–84*, 1958). Breeding biology for all species was briefly reviewed by Main, Lee, and Littlejohn (*op. cit.*). One other aspect of the breeding biology of these genera that requires preliminary consideration is male call structure. This aspect is important because of the probable role of call in the maintenance of reproductive isolation (Blair, *Amer. Nat. 92:27–51*, 1958; Littlejohn and Michaud, *Texas Jour. Sci. 11:86–92*, 1959). A study of call structure may also be of interest from a phylogenetical approach. Closely related species groups may share a common underlying pattern of call structure (Blair, *Texas Jour. Sci. 7:183–88*, 1955).

Tape recordings were obtained in the field and subsequently analyzed on a Kay Sonograph (Blair and Pettus, *Texas Jour. Sci. 6:72–77*, 1954). Calls of only one individual of each species were available for analysis, but those of numerous others have been heard by the authors, and the data presented are believed to be representative, but adequate only for a gross comparison. Call repetition rate was estimated by measuring with a stop-watch the time taken for an individual to make ten successive calls in a sequence. Timing was commenced at the end of a call

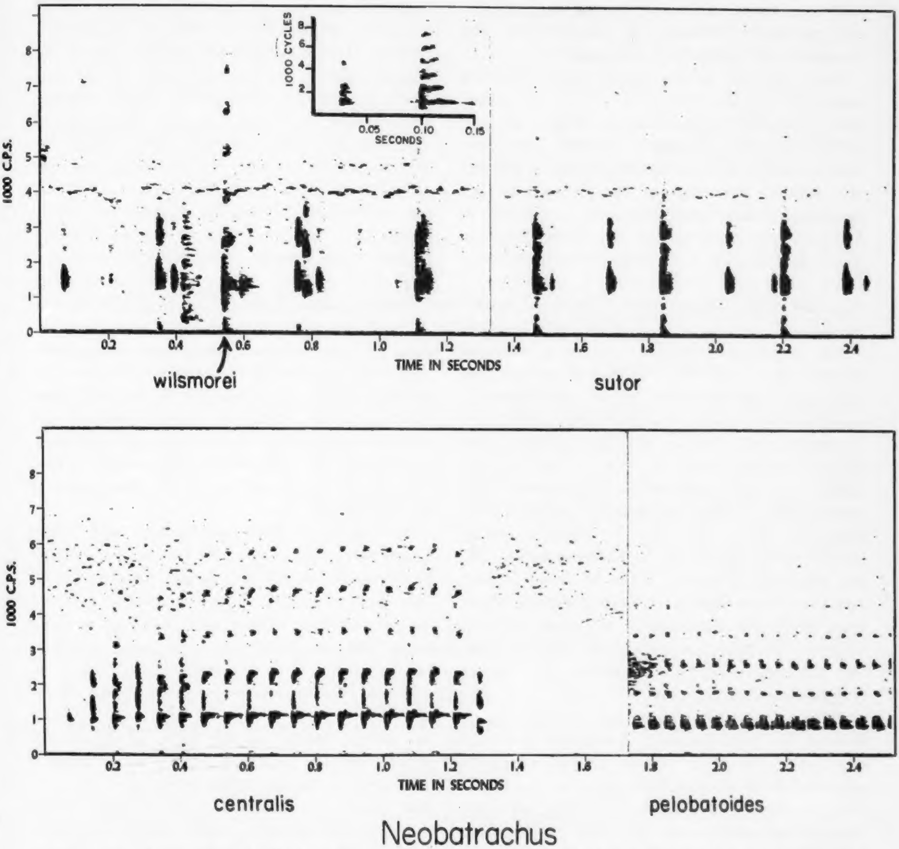

Fig. 1.—Sound spectrograms of calls of southwestern species of *Neobatrachus*. The call of *N. wilsmorei* is shown against a background of calls of *N. sutor*. Three calls of *N. sutor* are presented with another individual of the same species calling in the background. Only part of the call of *N. pelobatoides* is shown. The insert shows, on an expanded time base and a compressed frequency scale, a call of *N. sutor* (left), and *N. wilsmorei* (right). Frequency is given on the vertical axis, and timing on the horizontal axis. The darkness of the marking indicates the intensity of the sound.

Table 1

Physical Characteristics of Calls of Four Species of *Neobatrachus*

Species	Locality (Western Australia)	Air Temp. °C.	Water Temp. °C.	Duration (in seconds)	Number of pulses	Pulse repetition frequency (in pulses per second)	Approximate dominant frequency (in cycles per second)	Call repetition rate (in seconds)
sutor	Gnoolowa Hill	22.0	22.0	0.015	1	—	1500	4.0
wilsmorei	Gnoolowa Hill	22.0	22.0	0.04	1	—	1500	14.4
centralis	Morawa	16.0	14.5	1.25	19	15.0	1000	70.0
pelobatoides	Kojonup	17.0	14.0	3.60	70*	20.0	800	88.0

* Approximate

and continued until ten calls and ten intervening periods of silence had occurred, so that complete call cycles were obtained.

Call structure in the genus *Neobatrachus* is relatively simple. The calls consist of pulses, each probably representing a single damped oscillation. The tuning is broad and most differentiation between species occurs in number and rate of repetition of the pulses, and call repetition rate. Sonagrams are presented in Figure 1 and physical data are summarized on Table 1. The calls of *N. wilsmorei* and *N. sutor* consist of a single pulse which is more rapidly repeated in the latter (about 3.5 fold). *N. centralis* and *N. pelobatoides* emit groups of pulses (trills) repeated regularly during a call sequence. In *N. centralis*, the call is shorter (less than half the duration of *N. pelobatoides*), contains fewer pulses, is of lower pulse repetition frequency and is more rapidly repeated. Frequency analysis indicates that a clear fundamental and four harmonics are present, with most energy in the fundamental and first harmonic for these two species. *N. pictus*, probably an allopatric cognate of *N. pelobatoides* in eastern Australia, has been heard by these authors and some recordings have been obtained. However, these were unsuitable for sound analysis because of high ambient noise. Nevertheless, the calls appear to be very similar to those of *N. pelobatoides*.

Differentiation in the genus *Heleioporus* is evident in call duration, frequency and call repetition rate. The tuning of the frequency components is more precise than in *Neobatrachus*; a fundamental and from five to nine distinct harmonics may be clearly discerned. Some frequency modulation is evident. This is slight in the calls of *H. albopunctatus* and *H. inornatus*, pronounced in those of *H. psammophilus*. Marked amplitude modulation is apparent only in *H. psammophilus*, where each call is broken into three parts. Data in Table 2 are arranged in a sequence of decreasing call duration and call repetition rate. Except for *H. albopunctatus* and *H. inornatus*, the call duration of each species is greater than the one immediately below by a factor of 1.7 or more. Call repetition rate shows without exception even greater differentiation, each species differing from the one above by a factor of two or more. Differentiation is also evident in fundamental frequency, but not in concordance with the previously mentioned components.

TABLE 2

PHYSICAL CHARACTERISTICS OF CALLS OF FIVE SPECIES OF *HELEIOPORUS*

Species	Locality (Western Australia)	Air Temp. °C	Soil Temp. °C.	Duration (in seconds)	Approximate fundamental frequency (in cycles per second)	Call repetition rate (in seconds)
eyrei	Beechina	7.2	14.2	1.11	400	54.0
australiacus	Greenmount	12.0	—	0.42	200	17.2
albopunctatus	Meckering	15.8	17.2	0.25	700	8.5
inornatus	Sheepwash Creek	17.4	16.4	0.21	500	4.0
psammophilus	Beechina	7.2	14.2	0.11	1000	1.9

Possible premating isolating mechanisms (the genetic "Bars to Crossing" of Muller, *Biol. Symp. 6:71–125*, 1942), of anurans include differences in breeding seasons, sites and temperature; adult size; call and calling position. These will now be considered briefly for the species of the two genera.

Neobatrachus.—Each species has been found in sympatry with each of the others in some part of its range. Breeding seasons and sites of all four western species appear to overlap broadly. *N. pelobatoides*, calling and breeding at relatively low temperatures, is at least partially isolated from *N. sutor* and *N. wilsmorei*; *N. centralis* overlaps all three species (Main, *et al*; *op. cit.*). *N. sutor* males call from positions just out of the water, at the edges of temporary ponds, but the other species call while floating in temporary ponds. Adult body sizes are such that mechanical isolation between these species is considered unlikely. Since male call shows marked differences in at least one component, usually two, it is suggested here that, as in the other anuran groups so far analyzed (see Blair, 1958, *op. cit.* for a summary), the call differences may be operating at least initially as important premating isolating mechanisms.

Heleioporus.—All five species have been heard calling in close proximity on a few occasions, three or four together frequently. In the autumn, males of this genus call from burrows constructed by them in shallow depressions, which winter rains will later fill. Whereas there may be from species to species some preference for particular types of burrow sites, burrows of all species have been found interspersed. As with *Neobatrachus*, adult body sizes are such that no mechanical isolation can be expected. Male call however, is strikingly differentiated, and it is suggested that here also females are discriminating largely on differences in calls, at least ini-

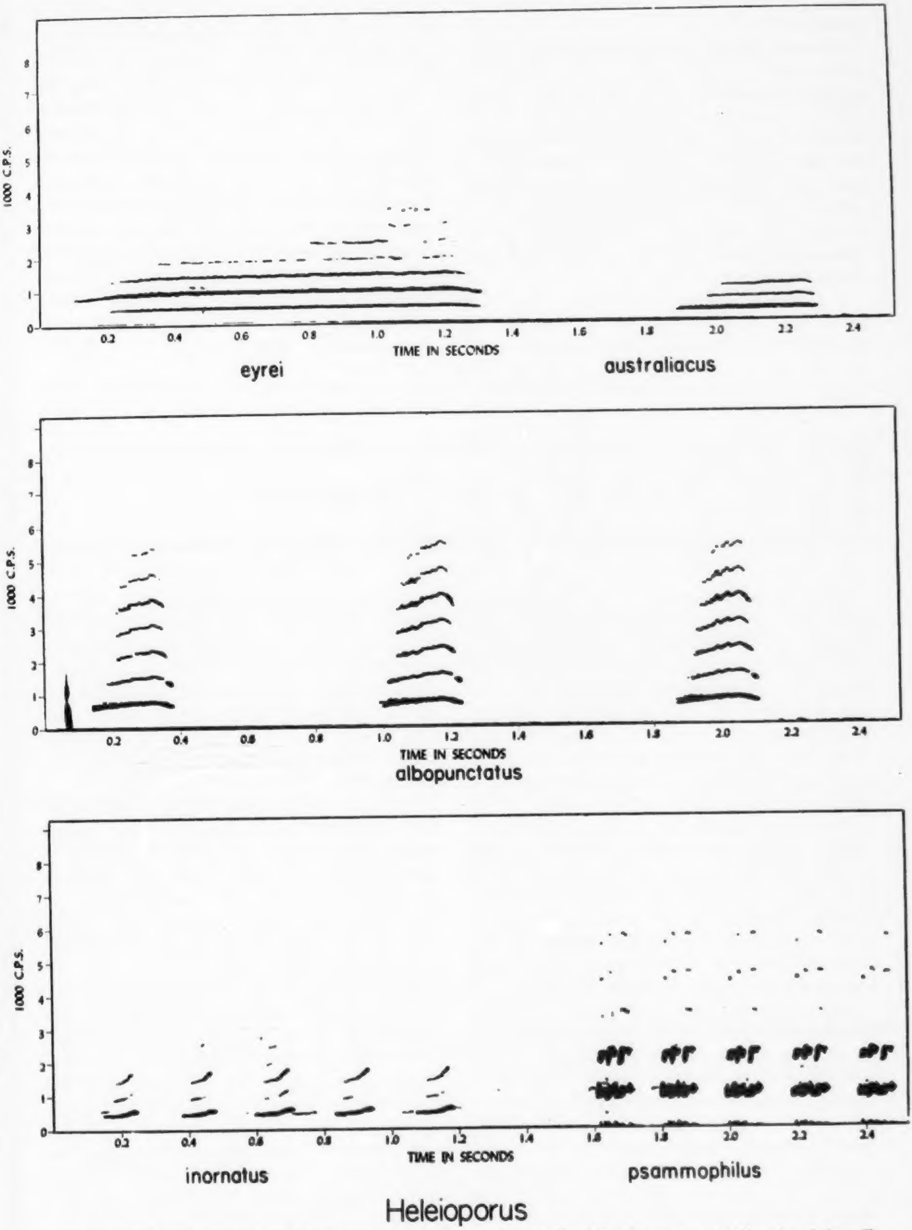

Fig. 2.—Sound spectrograms of calls of the species of *Heleioporus*. Three calls of *H. albopunctatus*, and five of each from *H. inornatus* and *H. psammophilus* are shown.

tially, since the males are concealed within the burrows.

Summarizing the premating isolating mechanism situation, it is suggested that efficient reproductive isolation is maintained at least initially by specific response of females to the distinct calls of males of their own species. Calls of related sympatric species differ markedly in at least one, usually two, components by a factor of two or more. Thus the differences are considerable in magnitude and generally on a temporal, rather than on an absolute frequency (pitch) basis.

It is also of interest to note that within each genus there is a characteristic pattern of call structure. Calls of species of *Neobatrachus* are of simple pulse structure, and the tuning is broad. Those of species of *Heleioporus* are unpulsed (but noting the amplitude modulation in *H. psammophilus*) and the tuning is very fine.

The field work was carried out on Research Grants from the University of Western Australia. We are indebted to Dr. W. F. Blair for making available the sound spectrograph.—MURRAY J. LITTLEJOHN, formerly *Zoology Department, University of Western Australia, Nedlands, Western Australia*; presently *Department of Zoology, University of Melbourne, Carlton N. 3., Victoria, Australia*; AND A. R. MAIN, *Zoology Department, University of Western Australia, Nedlands, Western Australia.*

REVIEWS AND COMMENTS

THE MORPHOLOGY AND CLASSIFICATION OF THE NORTHERN BLENNIOID FISHES (STICHAEOIDAE, BLENNIOIDEI, PISCES). By V. M. Makushok. Proc. Zool. Inst. (Trudy Zool. Inst. Akad. Nauk SSSR), 1958: vol. 25, pp. 3–129, 83 text figs.—Others who know the northern blennioid fishes at first hand will have to evaluate the classification proposed in this paper; the reviewer's interest lies in Makushok's approach to his subject.

The work summarizes a thesis dissertation. Makushok examined 28 of the 38 genera and 54 of the 72–75 species in his group; 510 specimens, 627 X-rays, and 106 skeletons were used. All but two of the good, if somewhat diagrammatic, figures were drawn by the author. Thirty-three Russian and 118 references in six other languages are cited in the bibliography.

After a historical review, there is a section on terminology. Next is a long portion dealing with trends of specialization in the different organ systems of the northern blennioids. The following structures are treated at some length: olfactory openings, scales, dermal appendages of the head, teeth and digestive apparatus, seismosensory (lateral-line) system, vertebral column, the various fins, pectoral and pelvic girdles, and skull. Makushok uses these analyses for establishing what, within the northern blennioids, are the generalized features and what have been the lines of specialization. These determinations form the basis of his classification. If the reviewer understands Makushok correctly, different lineages are allotted different higher taxa, but highly specialized endpoints along any one line of development are placed in the same taxon with its more generalized members. This is a very different concept of taxonomy from the ubiquitous one of clipping off as separate taxa the more aberrant entities and different again from that of judging the validity of higher taxa by the amount of difference between their type species.

The last whole section of the work deals with the individual groups (but not species) within the northern blennioids. In addition to the structures dealt with earlier other characters of special taxonomic value within groups are discussed. Synonymies, historical and nomenclatorial notes, and keys to families, subfamilies and genera are included.

A translation of the Russian portion of this paper has been made, and copies may be obtained from the Ichthyological Laboratory of the U. S. Fish and Wildlife Service, U. S. National Museum, Washington 25, D. C. However, this translation cannot very well be used without the original text, for lists of Latin names and tables with numerical data were not transcribed and the illustrations were not duplicated.—WILLIAM A. GOSLINE, *University of Hawaii, Honolulu, Hawaii.*

BEHAVIOR AND EVOLUTION. Edited by Anne Roe and George Gaylord Simpson. Yale University Press, New Haven, Conn., 1958: 557 pp. $10.—What an animal does—how it lives its life and behaves—has long been accepted as an

essential part of biology, especially by field naturalists and ecologists. However, the development of experimental behavioral studies on animals, and especially the linking up of such studies with animal and human psychology and with general biology, has scarcely begun. That a linkage between psychologists, behaviorists, and students of evolution is long overdue is obvious from the ofttimes naive evolutionary speculations of many psychologists and psychiatrists, and from the equally naive speculations about behavior and psychology often expressed by biologists. The book here noticed is the first full-dress attempt to review the interrelations between behavior and evolution.

The work is the result of two conferences held in 1955–56 under the joint auspices of the Society for the Study of Evolution and the American Psychological Association. There are 23 papers by 25 authors arranged under the following general headings: (1) The Study of Evolution and Its Record, (2) The Physical Basis of Behavior, (3) Categories of Behavior, (4) The Place of Behavior in the Study of Evolution, and (5) Evolution and Human Behavior. Such interesting subjects as psychoendocrinology, neurophysiological mechanisms, territoriality, social behavior, systematics, isolating mechanisms, natural selection, and human cultural processes are all linked to the central problems considered, by a group of eminent and able writers ranging from Romer, Emerson, and Pittendrigh to Tinbergen, Beach, and Margaret Mead. Simpson's introductory and terminal essays effectively round out the presentation.

To any zoologist interested in how and why animals behave as they do, this book is a stimulating one. Almost any naturalist who reads it will recall observations which supplement, extend, or call into question one or more of the accounts and interpretations given, or will discover things which illuminate his own research in a new way. To the present reviewer, the book is profoundly satisfying, even if long in coming, for he pointed out almost 30 years ago (*Micropaleo. Bull. 2(3):56,* 1930) that any exhaustive evaluation of phylogenetic relationships should be based upon study of every life process of the organisms concerned. He was then quite convinced that those life processes which we now lump under the term behavioral patterns were amenable to phylogenetic evaluation (see *Copeia 1934(2):100,* paper 10; *Stanford Ichth. Bull. 1:85–87*), and vindication of one's own beliefs is always pleasant.—GEORGE S. MYERS, *Natural History Museum, Stanford University, Calif.*

THE VERTEBRATE STORY. By Alfred S. Romer. Univ. Chicago Press, 1959: vii + 437 pp. $7.00.—This book is a much revised and enlarged edition of *Man and the Vertebrates,* and is similar enough to the preceding editions to require little comment. The major change is the deletion of the final section of the older editions, that dealing with human anatomy and embryology, and a corresponding increase in the discussions of other forms (The ichthyological and herpetological sections are roughly doubled in size). Another change is the addition of a small, but useful, bibliography.

As in the earlier editions, the illustrations should be one of the attractive features of this volume. Most of the old ones are present, and many new ones have been added. However with the recent appearance of several books devoted primarily to color photographs of various groups of animals, *The Vertebrate Story* does not seem as lavishly illustrated as did *Man and the Vertebrates.* This problem is increased by the use of many photographs of animals in zoos, but few of them in their native habitats. The drawings are almost all neat and useful; one exception which comes to mind is the page (205) of "thumbnail sketches of representatives of most of the orders of birds." However the many excellent "family trees" more than counterbalance that one. The text also resembles closely that of its predecessors—informally and well-written, but still surprisingly concentrated. There appear to be very few awkward spots, and I noticed no misprints except for one photograph. In any book, a reviewer can find some statement which startles or annoys him; in this one I was puzzled by the absolutely true, but very misleading, comment on the hepatic portal system (p. 118): "present in lungfishes and all land vertebrates." However since that is the only such statement I noticed, the author and publisher must be complimented on an excellent job.

Thus *The Vertebrate Story* should appeal greatly to those who wish to read an authoritative account of vertebrate evolution but who are not specialists in the field, as well as to specialists who desire a well-written and (relatively) non-technical survey of the vertebrates as a whole. It is probably more suitable for advanced high school than college students, and for supplementary reading than for a regular course textbook; certainly any high school library should possess at least one copy. Although it is a book which could be read, and with considerable enjoyment and profit, by people without formal training in biology, it is *not* a semi-popular work—despite a deceptively free and easy style, there is much substance, and most points are explained but once. Moderately careful reading, not casual and intermittent perusal, will be necessary for anyone encountering the material for the first time.

Editorial Notes and News

Moichiro Maki

Hajime Fukada informs us that Dr. Moichiro Maki died on April 19, 1959, at his home in Kyoto, Japan, at the age of 73 years. Dr. Maki was a professor of biology at Hanazono Buddhist College and a chief director of Koshien Girls' Schools. He is best known to ASIH members for his "Monograph of Snakes of Japan," published in 1931.

Announcements from E-C

The Governing Board at San Diego voted to discontinue Memorial Numbers of *Copeia* after the publication of the present issue. This Number is thus the last commemorative, and it is perhaps fitting that the final Memorial pays tribute to one who gave so much to his field and to ASIH. The lead article in the current issue reminds us of many of the attributes of Karl P. Schmidt, and the quality of the contributions to this Number reflects the esteem with which he was held by his colleagues. Many of us also admired Karl Schmidt for characteristics that were quite unrelated to his ability as a research zoologist. One of these was his constant effort to encourage and help beginning students and his ability to inspire them; another was his respected neutrality in the controversies between cliques, institutions, or between individuals within the Society.

The Board also voted to reduce the price on remaining copies of the "Check List of North American Amphibians and Reptiles, Sixth Edition" to $1.50. Copies may be obtained from the Publications Secretary, Prof. N. Bayard Green, *Biology Department, Marshall College, Huntington 1, West Virginia*. Members of ASIH should advise colleagues, students, and others who may be interested in this price reduction and encourage them to act quickly before the supply is exhausted.

The Editor wishes to call the attention of all ASIH members to two particularly important announcements concerning activities of the Philadelphia Herpetological Society. This active group has arranged an **emergency antivenin service** and effected an **exchange of publications** with the Institute of Scientific and Technical Information in Peking, China. These services are described in greater detail under **PHSB** in the present issue.

News Notes

Dr. Bernard Greenberg, chairman of the biology department at Roosevelt University, Chicago, has been awarded a $53,000 research grant to continue his studies into the reproductive behavior and physiology of fishes. Dr. Greenberg, a former Fulbright fellow, seeks to measure the frequency and intensity of courtship movements and to relate these movements to ovarian and testicular cycles. The grant, awarded by the United States Public Health Service, runs from December, 1959, to December, 1964. It is a continuation of an earlier grant given in 1957. Dr. Greenberg is a former research assistant with the American Museum of Natural History and took his Ph.D. at the University of Chicago. He came to Roosevelt in 1945 as an instructor, became a full professor in 1955, and was named department chairman in 1956.

Dr. J. A. Taub, Regional Fisheries Officer for Asia and the Far East, Food and Agricultural Organization of the United Nations, Maliwan Manion, Phra Atit Road, Bangkok, desires to complete the set of *Copeia* in the Regional Office, and he requests that ASIH members who may have duplicate copies of 1943(2), 1946(1), and 1952(4) that they would be willing to donate or sell, contact him or his office. Dr. Taub notes that, according to Prof. N. B. Green, the desired numbers are no longer available through the Society. He is most anxious to obtain these copies to complete their run of *Copeia*.

Dr. Fred R. Cagle advises that copies of the report "Herpetological Terminology," prepared by Dr. Albert Hazen Wright, are available free of charge to members who care to contact Dr. Cagle, *Coordinator of Research, Tulane University, New Orleans, Louisiana.*

Dr. James A. Oliver, Director of the New York Zoological Park since June of last year and Curator of Reptiles since 1951, has accepted an appointment as Director of the American Museum of Natural History. He will assume his new post on September 15. Dr. Albert E. Parr retires as Director of AMNH but will occupy the newly-established position of Senior Scientist so that he may continue with his research on marine biology. Dr. John Tee-Van, General Director of the New York Zoological Park and the New York Aquarium since 1956, will again assume full directorship of the Bronx Zoo. He had been Director of the Park from 1952 to 1956. Dr. Herndon G.

DOWLING, Associate Professor of Zoology at the University of Arkansas, will take charge of the Reptile Department, New York Zoological Park on August 1, 1959, as Associate Curator of Reptiles.

DR. VADIM D. VLADYKOV is now associated with the Department of Biology of the University of Ottawa, Ottawa 2, Canada. He recently terminated twenty years of work with the Department of Fisheries in Quebec. He has accepted a position as professor of biology at the University of Ottawa. DR. VLADYKOV is still very much interested in the American eel, *Anguilla rostrata*; and in continuing his studies on this fish, he would appreciate receiving any material, obtained in the sea at least ten miles offshore.

DR. KEPPEL H. BARNARD, former director of the South African Museum and well known for his researches on fishes of South Africa, writes from Cape Town: "Fishes have gone out of my purview. The Museum has a marine biologist whose specialty is fishes... MR. FRANK TALBOT, who would appreciate corresponding with ichthyologists. I am continuing at the Museum as an Honorary Worker, and devoting myself to marine mollusca."

American Institute of Fishery Research Biologists THE growth of population throughout the world is placing heavy demands upon our natural resources, including fisheries. Maintaining stocks of fish has become a critical necessity for many nations. The biological sciences must be directed to fisheries problems to answer this challenge and provide a sustained supply of fish for both the economic and recreational needs of the people.

To give substance and distinction to the vital field of fisheries biological research, a professional society known as the American Institute of Fishery Research Biologists was established and incorporated in the State of Washington on the 27th day of December 1956, by a group of nationally known fishery scientists of Canada and the United States. The purposes of the Institute are: (1) To promote the conservation and proper utilization of fishery resources by advancing the theory and practice of scientific fishery biology, and (2) To maintain high professional standards; to recognize achievement; and to adhere to a code to be known as "Principles of Professional Conduct for Fishery Biologists."

The Institute is organized like those representing other professions, such as the American Bar Association and the American College of Physicians. It provides for the election of Fellows, Members, and Candidates.

The bylaws of the Institute provide for the regionalizing of Canada and the United States, each region having a vice president. Within each region there will be districts, each with its director. The regional vice presidents and district directors are members of a national Board of Control.

The national framework of the organization having been completed, the Institute is now designating local working districts. In response to a petition by Institute members residing in the northwest portion of the State of Washington, the Board of Control, consisting of W. F. THOMPSON, *President*, Seattle, Washington; KENNETH D. CARLANDER, Ames, Iowa; and JOHN L. HART, St. Andrews, New Brunswick, Canada, have designated that area as a district. This is the initial district to be formed on the continent. Other areas in Canada and the United States are expected to follow suit.

At a dinner held in Seattle on June 1st the district was officially chartered. Communications from interested ASIH members should be addressed to: F. HEWARD BELL, *Secretary-Treasurer, International Pacific Halibut Comm., University of Washington, Seattle 5, Washington.*

Beaudette Foundation THE recently organized Beaudette Foundation for Biological Research, of Solvang, California, is planning to expand its operations to include studies of the fauna, including the fishes, of the lagoons along the west coast of Mexico. DR. E. YALE DAWSON, phycologist, is Research Director of the new institution, and J. LAURENS BARNARD, invertebrate zoologist, and RAYMOND M. GILLMORE, mammalogist, are Research Associates. Expansion of the staff is planned. General biological surveys are prospected for the Pacific coast of Latin America, as far south as Peru.

India Marine Biological Association THE Marine Biological Association of India was founded at Mandapam Camp, to promote interest in marine biological and cognate sciences. The Association was formally inaugurated by the Honorable MRS. LOURDHAMMAL SIMON, Minister for Fisheries and Local Administration, Madras State, on January 3, 1959. The following officers were elected: DR. S. JONES (President), PROF. R. V. SESHAIYA (Vice-President), DR. R. PRASAD and DR. C. P. GNANAMUTHU (Secretaries), DR. R. P. VARMA (Asst. Secretary), SHRI. K. V. RAO (Treasurer), DR. P. N. GANAPATI (Editor), DR. R. SUBRAHMANYAN (Joint Editor), and DR. S. V. JOB (Managing Editor). The official organ of the Association, the *Journal of the*

Marine Biological Association of India, is expected to be issued half-yearly. Membership is open to all interested. All correspondence may be addressed to the Secretary, *Marine Biological Association of India, Marine Fisheries, P. O., Mandapam Camp, South India.*

PHSB THE Philadelphia Herpetological Society again invites attention to its *Bulletin*. Recent issues of this bimonthly, internationally circulated newsletter (March and May) featured distributional surveys of the states of New Jersey and Illinois. These surveys, part of a series, are published as supplements to the *Bulletin*. Prepared by state authorities, they include a complete state check list, cross-graphs of county records, discussion of problems and a county outline map of the state. The principal purpose of these supplements is to aid in the gathering of data on the distribution of amphibians and reptiles. The Pennsylvania supplement, published in March, 1958, has added 50 new records to date to Carnegie Museum's survey of the Pennsylvania herpetofauna. These supplements also provide an incentive and guide to younger members by indicating to them how they can make worth-while contributions to our knowledge of herpetology.

The distributional surveys are only one of the salient features of the PHSB. Regular features include news and collecting notes, articles, book reviews, and a classified section. The PHS *Bulletin* presently circulates to 400 subscribers in the U.S. and 14 countries. The success of this newsletter is apparently due to its level of writing; it contains items of interest to both amateur and professional herpetologists.

The Society, in cooperation with Wyeth Laboratories, Inc., and The Institut Pasteur, recently established an **emergency antivenin service.** Antivenins for treatment of bites from all North American venomous snakes, cobras and coral snakes are available on a round-the-clock basis. The sera are for emergency use only; they cannot be borrowed or exchanged. In the event of a bite (and if antivenin is not locally available) the Society may be contacted in Philadelphia by 'phoning PIlgrim 2-9498. If no answer, call LIncoln 7-5798 in Haddon Heights, New Jersey. Arrangements for jet-transport of serum to any part of the U.S. will be made by the Society. There is no charge for either antivenin or transport. The emergency antivenin service is open to both members and non-members of the PHS.

The Society has recently been able to effect an **exchange of publications** with the Institute of Scientific and Technical Information of China, in Peking. It is receiving the *Acta Zoological Sinica* and *Science Abstracts of China* (Biological Sciences Section) in exchange for the PHS *Bulletin* and *Copeia*. The PHS desires to further exchange of information in the fields of ichthyology and herpetology between the two countries, and offers to make photostatic copies of pertinent Chinese abstracts and papers available to American zoologists. Abstracts are in English, papers in Chinese with English summaries. Write for a list of titles. Support, by becoming a member of the PHS, would be appreciated from those ASIH members who take advantage of this service. Rates are as follows: Membership, which includes a subscription to the *Bulletin*, is $2.00 a year for adults, $1.50 for minors. Foreign rate is $3.00/year. Sustaining Membership, $10.00/year. Address all correspondence to: PHS, *7036 Rising Sun Avenue, Philadelphia 11, Pennsylvania.*

Rephibia *Rephibia*, published monthly by the Metropolitan New York Herpetological Society will shortly begin an experimental idea in the publication of herpetological literature. It will call for a synopsis of all current scientific literature regarding reptiles and amphibians in all journals, as well as a herpetological digest including humorous essays, poems, and reptile news gleaned from the newspapers and popular magazines. Persons interested in doing synopsis work should contact the editor, S. GRENARD, *8525 Shore Road, Brooklyn 9, New York.*

The Metropolitan New York Herpetological Society announces its new slate of officers: HARVEY POUGH, *President*; E. J. WEISS, *Vice-President*; LUCY EHRLICH, *Secretary.*

Ohio Herpetological Society THE Ohio Herpetological Society calls attention to its publication, the *Journal of the Ohio Herpetological Society*. It is lithographed and issued two or three times yearly. It frequently contains line drawings as well as photographs, and consists primarily of scientific articles on Ohio herpetology. Individual rates for the United States and Canada, $1.00 per year; Foreign individual, $1.50; all Institutions, $1.75. Correspondence regarding the journal and the Society should be addressed to KRAIG K. ADLER, *Chairman, OHS, 2370 Club Road, Columbus 21, Ohio.*

COPEIA IS THE JOURNAL OF THE AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS

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The American Society of Ichthyologists and Herpetologists is a member of the American Institute of Biological Sciences and of the Division of Biology and Agriculture, National Research Council, and is an affiliate of the American Association for the Advancement of Science. An annual contribution is made to the publication of the Zoological Record.

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